MODERN ROAD BUILDING

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BEING REPORTS OF THE TRANSACTIONS

OF THE

FIRST CONGRESS OF AMERICAN ROAD BUILDERS

HELD AT SEATTLE, WASHINGTON

JULY 4, 1909

E. L. POWERS, SECRETARY, A. R. B.
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INVOCATION

Delivered by the Rt. Rev. Frederic W. Keator, D.D., Bishop of Olympia, at the Opening of the First Congress of American Road Builders, Seattle, July 5th, 1909.

"O God, our Help in ages past,
Our Hope for years to come."

We lift our heart and mind to Thee in humble adoration and grateful praise.

We acknowledge Thee the Giver of all good gifts, the Inspirer of every good word and work.

We thank Thee for all the manifold blessings bestowed on us as a nation.

In all our progress we would see Thy guiding hand. We pray Thee help us to show forth our gratitude to Thee by a humble walking before Thee all our days, and by a sincere obedience to Thy laws.

We ask Thy blessing upon all who are in authority over us, and especially the President of the United States and the Governor of this State.

Help them and us, remembering whose authority they bear, to do Thy will and set forward Thy kingdom.

Grant Thy blessing to this Congress now assembled. Direct them in all their doings and further them with Thy continual help, that in all their ways they may acknowledge Thee. For Thine is the Kingdom, and the Power, and the Glory for ever. Amen.

George E. Dickson, Chairman of the Washington State Commission, then presented the Washington Good Roads Building to the University of Washington. It is intended that this building shall be used by the University as a lecture hall and in the furthering of highway engineering, which is a subject now in which the students of the University are trained under the able direction of Professor Samuel C. Lancaster.

Mr. Dickson made the presentation in the following happy terms:

ADDRESS OF GEORGE E. DICKSON.

Mr. President and Gentlemen of the First Congress of American Road Builders:

As the official representative of the Washington State Commission to the Alaska-Yukon-Pacific Exposition, it gives me great pleasure to welcome you to the Washington State Good Roads Building.

I assure you it would be especially gratifying to the Washington State Commission, and the people of the state, if this building was known as the official home of your organization.

The Washington State Commission was created by act of the Tenth Legislature for the purpose of exhibiting the general developments, resources, and advantages of the State of Washington, at the World's Fair of the Alaska-Yukon-Pacific Exposition, to be held in Seattle, Washington, in 1909.

Seven of the beautiful buildings you see on the exposition grounds were constructed by this Commission, yet the Washington State Good Roads Building may prove the most important in the development and upbuilding of the state.

The original appropriation of $2,500.00 set aside by us for a Good Roads Department did not contemplate the construction of a building, but only an exhibit of road materials and road building.

Owing to the great interest taken in the good roads movement throughout the state, fostered and promoted by Mr. Samuel Hill, President of the Washington Good Roads Association, and from the fact that the Washington State University had established a chair of "Good Roads" in that great institution of learning, the Commission, believing the construction of a building devoted to good roads and the installing of its good roads exhibit therein, would be a powerful aid in the promotion and education for good roads, concluded to construct this beautiful building, known as the Washington State Good Roads Building, at a cost of $12,000.00.

This building is a permanent building, built on a substantial concrete foundation, and will be used by the State University as the home of its "Good Roads Department."

During the exposition it will house and be the home of the Washington Good Roads exhibit, and its auditorium and lecture room will be used each day for lectures and classes in good roads.

The building is designed and arranged particularly for educating the people as to the necessity for good roads.

This Commission and the people of the state at large are especially pleased that the first session of the American Congress of Road Builders will be held in this building, the first edifice of the kind to be built for the purpose of fostering and promoting the building of good roads.

Gentlemen, on behalf of the Washington State Commission, for the Alaska-Yukon-Pacific Exposition, I take great pleasure in dedicating this building to the purpose for which it was erected, viz., "Good Roads."

It used to be said that all roads lead to Rome. I trust that the future may show that all "Good Roads" emanate from the Washington State Good Roads Building.

Dr. Thomas Franklin Kane, President of the University of Washington, in accepting the gift of the State Commission, said:

Mr. Dickson, Chairman of the State Commission of the Alaska-Yukon-Pacific Exposition:

As a citizen of the state, along with every other citizen of the state, I wish to express my appreciation of the work of your Commission and the plans of the Exposition, whereby the state will receive for its appropriation to the Fair so large an amount of property of permanent value. Your Commission is to be congratulated on this signal service to the state.

As representing the University, I wish to accept at your hands, for the state and for the University, this substantial and useful building. It has been planned by practical good roads engineers. It is well suited to its purpose. It is a happy coincidence that at the time of its dedication to its permanent use it is serving as the meeting place for the first Congress of American Road Builders.

In accepting this building for the University, to you, Mr. Dickson, for your Commission, and to you delegates assembled in this Congress, I pledge the University to do everything that can be done on our part toward having this building serve its intended purpose.

It is a great pleasure to me, as a representative of one of the first Universities in this country, if not the first, to establish a chair of Good Roads Engineering, to be present at the first Congress of American Road Builders. It is an added cause of pleasure to have this first Congress assemble on the campus of the University. It is consistent with the policy of the University to provide for Good Roads Engineering. As a State University, it is our purpose to make the University of the highest possible service to the people of the state. The aim of the University is to help prepare young men and women for the work that will be of the greatest benefit to the state.

The movement which this Congress represents, and which it is to advance, is one of the most important movements of our time, one that will result in as great benefit to the state as any that has taken place in years.

The importance of this work in the state cannot at this time be measured. Commercially, good roads will enhance the value of every acre of agricultural and timber land in the state. It will increase the business of every town in the state. It will add to the value for the producer of every dollar's worth produced in the state. Good roads mean for the farmer and for all business dependent upon local transportation approximate uniform business the year round—a whole year for business, instead of, as at present, business for the months in which the roads are good. Good roads will be one of the greatest inducements possible toward bringing to our state for permanent residence desirable classes of citizens, and our state will have the advantage, immediate and remote, such as California now abundantly enjoys, of travelers and visitors visiting our great state and seeing its attractions to advantage.

Socially, it will mean that the children can go to school, that people can go to church, that the rural mail carrier can deliver mail in every section of the state in every month of the year. It will mean another approach of country life to all of the advantages of city life, with none of the added disadvantages. It will mean that the workingman in the factories of the city may be able to go back and forth from his work to a home in the country with wholesome, healthful surroundings for bringing up his children. Generally, good roads mean likewise healthful exercise and enjoyment, attraction to the millionaire, and within reach of the humblest citizen in the state who can command the use of a vehicle, or even a bicycle.

This work will stand in this country as a monument of the energy, the generosity, and the practical ability of the men who have taken an active part in these Good Roads Associations. Your work will long be remembered in the states and countries which you represent, and I trust that you may have the full enjoyment and satisfaction that come from having taken an active part in the accomplishing of work so beneficial for all time to your respective states.

ADDRESS OF WELCOME.

Governor M. E. Hay, of Washington State, whose rising was received with loud applause, then proceeded, on behalf of the state of which he is the head, to welcome the many delegates who were in attendance. Nearly every state in the Union was represented, and the Governor's remarks were of a character both hearty and sincere, and he concluded by wishing the Congress every success, and by expressing the hope that their efforts and deliberations would be productive of much good in the improvement of the roads of the state and the United States generally.

Governor Hay said, in part:

The state of Washington is indeed glad to welcome you who represent an organization that has for its object a movement fully as important as the reclamation of the arid lands of our country and the conservation of our natural resources. I know that your meeting here will give added impetus to the growing interest in the Good Roads movement in this state. The problem of providing improved highways is worthy of the most serious consideration on the part of every state of our Union. Better transportation facilities in our rural districts is of vital importance, and the propaganda of education in the construction of durable roads which you are carrying on must ultimately prove of inestimable value to the nation.

Among the nations of the first rank the United States is far behind in road building. Government statistics show that, whereas

it costs from seven to eight cents to transport one ton one mile over the improved roads of Europe, the average cost per ton per mile over the roads in this country is twenty-five cents. In this respect the United States ranks with Mexico. It is estimated that the annual cost of transportation over the common roads in this country reaches the enormous sum of one billion dollars. If, through proper construction, the cost of hauling over the roads in this country could be reduced to an equality with that in Europe, and a saving of two-thirds of a billion dollars might be effected, it is simple arithmetic to figure how much we can afford to expend in attaining this great economic saving. There are many other considerations besides the added profits from labor accruing from a reduction in the cost of transportation to urge in making an appeal for good roads. Improved highways mean increased population, easier facilities for communication, and consequently better social conditions. They also add to the value of the adjacent land and to the profit on every product marketed therefrom.

In rural districts, where the population is sparse, which is the condition in many sections of this state, the expense of building good roads is prohibitive, unless assistance can be received from other sources. The rapid development that naturally follows the improvement of transportation facilities adds directly to the taxable wealth of the state, and consequently decreases the general burden of supporting the state government. Every step in the development of the rural districts directly benefits the town to which they are tributary, and indirectly the larger centers of population, which profit from the increased commerce originating from the farms, the lumber camps, the mines, and from the grazing districts. All the communities, therefore, which gain from an increased development, and the state as a whole, which profits indirectly, are willing to aid in the construction of good roads. This willingness is expressed in the state aid road law now on our statute books, and I believe that law is a wise and beneficial piece of legislation, one which is calculated to do much in adding to the value of farm lands and the profits derived from all industries such as I have enumerated, and consequently to the welfare of the entire state.

Very much of the credit for the good roads legislation now on the statute books of our state is due Mr. Samuel Hill, and I desire to take this opportunity of acknowledging the splendid service he has rendered the people of Washington as President of the State Good Roads Association. The campaign of education in road building and agitation in creating a lively interest in this important economic question carried on by him has been inspired by purely patriotic and philanthropic motives. In this work, to which he has so enthusiastically and effectively devoted himself, Mr. Hill has earned the right to a prominent place among the most useful citizens of the state of Washington.

The state of Washington, with its great area, is confronted with a big problem in providing all sections with improved highways. Our people are bending their energies to solving that problem, and welcome every opportunity to acquire reliable information and

practical suggestions bearing on the question of the economical construction of country highways. The efforts of your organization are bearing fruit in all parts of the United States, and you will find here an intelligent appreciation of the work you are doing.

OBJECTS AND PURPOSES OF THIS CONGRESS.

"The Objects and Purposes of this Congress" was the subject of the address of **Hon. C. H. Hanford,** of Seattle.

Address by Judge C. H. Hanford.

The object of this Congress is educational, practical, and stimulative. A country's roads are to it important as a man's veins and arteries are to him; each affords the means of circulation necessary to life. All people have a vague notion of the importance of public highways, but few have that degree of knowledge necessary to create a belief as to the necessity or wisdom of providing and maintaining roads of the quality essential to the use thereof with convenience and economy. The work of constructing and maintaining them requires men of scientific attainments, acting under the guidance of statesmen, who act most efficiently under the spur of popular demands. Those who use the highways and injure them most ascribe their deficiencies to the negligence of local officials, and are not conscious of any personal responsibility. Hence the necessity for action to challenge public attention and to teach the masses of the people with respect to the importance of having good roads and how they must be made.

Road construction is a progressive science. Before the time of McAdam, the roads of England were very bad; that is to say, they were unfit for the use then required. Then improved methods of construction were devised, and the roads were greatly improved, and they were good roads for a time; but they proved to be incapable of resisting the destructive forces of modern methods of rapid transit, so that Necessity, the mother of invention, has been required to bring forth new theories and new materials for road construction. I have referred to England, for the reason that I am informed that she leads all other countries in the construction of roads fit to endure the wear of swift-running automobiles and heavy traction engines which are used there.

Knowledge acquired by experimental processes is very costly. Much time and wealth may be saved by an interchange of ideas; that is to say, for the thinkers and successful experimenters of different localities to disseminate the knowledge which they have acquired for the general welfare. With this in view, the object of this Congress, the first of its kind to be held on the continent of North America, is to serve as a medium for the interchange of ideas and the dissemination of knowledge. It is the medium through which some of the greatest practical thinkers of our time are to speak to the whole world on the important subject of road build-

ing. Seattle has been highly honored in being selected as the city in which the first American Congress of road builders shall be held. The city appreciates the honor and cordially welcomes all who have come, from near and from far, to participate in the noble enterprise of enlightening the world.

In conclusion, permit me to say that credit for this Congress is due to one man, whose name has already been mentioned with commendation—Mr. Samuel Hill. With patriotic and unselfish zeal he devotes much of his time and is generous financially in promoting the cause of good roads. He engages in this work because he likes to do it, and he likes to do it because he realizes that thereby he is assisting in doing what is best for his fellow men. Hereafter, when Europeans, or our own countrymen, speak in derision of Americans as worshippers of the Almighty Dollar, we may justly claim that there are Americans who prefer to spend the money which they have to lighten the burdens and enhance the joys of all people, rather than to accumulate more wealth, and among men of this stamp Samuel Hill is the leader.

James J. Hill was scheduled on the programme to give an address on "Primary Transportation," but was unavoidably prevented from coming to Seattle. This was a cause of extreme regret to the delegates.

HISTORY OF ROAD BUILDING IN THE UNITED STATES.

Mr. E. L. Powers, of the "Good Roads Magazine," of New York City, then read a paper on the "History of Road Building in the United States," which is here printed in full.

Paper by Mr. E. L. Powers.

The subject assigned me is one with which all here assembled are more or less familiar. Our public roads are an evolution from the primary paths made by animals and by men. Of the identity of the first beings who made paths in the wilderness we are uncertain. Whatever their character and origin, we may be reasonably certain that they had roads of some sort.

It cannot be positively asserted that the mound-building Indians made roads, but that such was the case seems not unlikely. Several circumstances indicate that they had some system of communication. The remains of their works are often found on streams that were not navigable, and groups of them are found concentrated about natural strategic points, such as mountain passes, thus making natural the inference that some avenues of overland travel existed.

The buffalo herds made broad, straight paths from point to point, which can yet be traced. These animals instinctively chose the best routes, and in many cases it has been found impossible to improve upon them. The Indians used these thoroughfares for many of their trails, and later the white man, finding them good, appropriated them to his own use. The first white settlers to start with had very little to transport. Therefore a path to accommodate the pack horse was sufficient for their needs. As population grew and the country became civilized, more commodities had to be moved, and the wagon superseded the pack train. This necessitated widening the former paths, and when it was found that the soft earth road would not sustain the wagon traffic attention was then given to the roadbed. The first step in this direction was the construction of the corduroy road, made by the use of saplings and logs. This was a step forward, although it is possible that some of you have ridden over such roads and know by experience that they do not compare very favorably with at least some of our roads to-day.

Road building began at centers, and spread out with the spread of population. Probably the real work of opening the roads in America began with the bridle paths on the Atlantic Slope. In 1639 a measure was passed in the Massachusetts Bay colony which provided that two or three men from adjacent towns get together and lay out proper roads. They were instructed to place the roads where they might be most convenient, and those deputed to the work were to have the power to locate them wherever they chose, provided that it did not necessitate pulling down a man's house or going through his garden or orchard. These men seem to have been (about) the first highway commissioners of whom we have record.

In 1664 the government of the then province of New York adopted regulations for road making. These are the specifications:

> "The highways to be cleared as followeth, viz., the way to be made clear of standing and lying trees, at least ten feet broad; all stumps and shrubs to be cut close by the ground. The trees marked yearly on both sides—sufficient bridges to be made and kept over all marshy, swampy and difficult dirty places, and whatever else shall be thought more necessary about the highways aforesaid."

In Pennsylvania, in 1692, the townships were given the control of the roads, and eight years later the county roads were put in the hands of county justices and King's highways in the hands of the governor and his council.

Previous to the time of the Revolutionary War, it can be said that almost nothing had been done towards what we to-day understand by the term road building. In 1790 it is estimated that there were nearly 1,800 miles of post roads in the United States. As stated, road improvement began at the centers of the settlements and spread out as population increased. Philadelphia was one of the principal centers. Many roads began there, and were extended further and further. It is noticeable that in corduroying the roads the tendency was to narrow and deepen them—in fact, one his-

torian relates that they were made so deep that an instance is given of where, in trying to get a team out of a mudhole with a chain around the horse's neck, they pulled half the horse's head off.

The advent of the stagecoach and freight wagon brought about another era in road building. This caused much friction between the pack horse owners and the stagecoach and wagon men—a thing which always has and probably always will happen when a radical change is made in methods of transportation. We see the principle illustrated to-day in much the same way in the advent of the automobile. The adoption of the stagecoach ushered in the macadamized road, or, as it was known at that time, a road made of layers of broken stone. It is true, however, that but few such roads were built at the time. Most of the old roads were merely widened and graded by state and county, but remained of dirt.

Nearly all of the macadamized roads were built by road and turnpike companies. It is claimed that the first and most interesting macadamized road in the United States was the old Lancaster Turnpike, which ran from Philadelphia to Lancaster, Pa. This road was built by the Philadelphia & Lancaster Turnpike Company, its charter being granted April 9, 1792. The work of building began immediately, and was completed in 1794, at a cost of $465,000. The road was built very straight, with regular slope transversely. The macadam was carefully prepared, and no stone was allowed on the road that would not pass a two-inch ring. It was first planned to make the road 100 feet wide, but this was found too expensive.

The toll gate, or turnpike, still exists in many isolated sections of the country, but gradually they are passing. A number of states are now arranging for their complete extinction.

In 1750 there were three routes running through Southwestern Pennsylvania, Central Pennsylvania, and Central New York. These roads are said to have been wide enough for two pack horses to pass. In 1755 two roads were opened westward by troops of Washington, Braddock, and Forbes. These were long trails, widened by pack horses of the Ohio Companies' agents. Braddock's road was cut through in 1755.

In the year 1799 the state of Virginia appointed commissioners to construct a road over the Cumberland Mountains to the open country in Kentucky. These commissioners were authorized to call on the local county authorities for guards to protect the workmen from the Indians. Commissioners were appointed in 1785 to open a wagon road from the head of James river in Virginia to Lexington.

Kentucky became a state in 1792, and passed its first road law in 1797, a law very similar to that of Virginia, which was in turn an adaptation of the English road law. Under its provisions, applications were made to the county court to open a road to the County courthouse and to other points. Three persons, termed "viewers," were appointed to examine the road and report on same as to the comparative advantages and disadvantages. For the general supervision and care of the roads, the county divided them

into precincts, each consisting of a certain number of miles, over which an overseer or surveyor was appointed. It was the overseer's duty to look after repairs. With some modifications, Kentucky operated under this law until 1894. It is stated that the public system of Macadam and Telford roads was begun as early as 1810, although other authorities claim that no macadamized road or turnpike had been constructed in the state prior to 1829.

From about 1822 to 1850 Kentucky gave liberally towards building roads, and many miles of both gravel and macadam were constructed. Some, like the road between Lexington and Frankfort, were built directly by the state; but in the greater number of cases the state contribution was in the form of the purchase of shares in turnpike companies. By these means the state paid for road building, between 1822 and 1860, nine million dollars.

When by act of Congress Ohio was admitted into the Union as a state in the year 1802, one of the provisions, to become binding on the United States as soon as the Ohio convention should accept it, was one providing that one-twentieth part of the net proceeds of the lands lying within the state sold by Congress from and after a certain fixed date should, after deducting all expenses incident to the same, be applied to the laying out and making of public roads leading from the navigable waters emptying into the Atlantic, to the Ohio, to the said state and through same, such roads to be laid out under the authority of Congress with the consent of the several states through which the roads should pass. The measure became a law and was accepted by the Ohio convention November 29, 1802.

Soon after the beginning of the last century, the matter of building the road from Cumberland to St. Louis was agitated. The result was that by a special act of Congress in 1806 the President was authorized to appoint a commission of three to lay out a road four rods wide from Cumberland, on the north bank of the Potomac river, to a point a little below Wheeling. This road is known as the "Cumberland Road," or the "Old National Pike." As originally planned, the road was to go from Cumberland to St. Louis, a distance of 1,000 miles. Only about 800 miles, however, were completed. Thirty thousand dollars were first appropriated for carrying on the work. In the year 1819 the appropriation was $500,000, and the last appropriation for the road made by Congress was in 1838 for $150,000. The total amount expended up to that time was $7,000,000, $680,000 of which was from the Ohio fund.

The Old National Pike was built of macadam, the depth of metal being 18 inches in the center and 12 inches at the sides. It was a toll road, and the revenues received were applied to repair and maintenance. In Ohio the amount collected in the year 1839 was $62,446.10, and this seems to have been the banner year. The average cost of the road between Cumberland and Uniontown was $9,745 per mile, while that of the division east of the Ohio river was about $13,000 per mile. This cost included the heavy grading and stone bridges which were built. The average cost of the road in Eastern Ohio was much less than in Maryland and Pennsyl-

vania, being about $3,400 per mile, and this included macadamizing, masonry, bridges, and culverts. Although the road was projected and partially surveyed in 1806, it was not thrown open to the public until the year 1812.

In about 1852 the development of the railroads took from the National Pike the bulk of travel and traffic, as well as the mails between the East and West. Thus began the period of decline of the most famous road in our history.

Many interesting debates took place in Congress in relation to the construction of the National Pike. Henry Clay was one of the most ardent advocates of the measure. An argument used in one of his speeches was that when the Cumberland Roads and the State Road from Baltimore to Cumberland should be completed the journey from Baltimore to Wheeling would be reduced from eight days to three days.

In 1804, 1805, and 1806, through the favor of the National Congress, the Lewis and Clark Expedition was organized, for the purpose of establishing a route from the Atlantic to the Pacific by following the Missouri to its source, and crossing to and following to tidewater the great river which forms the southern boundary of the state of Washington. Great credit is due Meriwether Lewis and Captain Clark and their company of explorers in carrying out this work. Praise is also due to John C. Fremont, the eminent engineer, who in 1844 surveyed a route to these shores through what was then named the South Pass of the Rockies. While not road builders in the strict sense of the term, these determined men made the famous trails of history that were primarily important factors in the establishment of avenues of traffic, thereby making possible the magnificent development of the Pacific Slope.

In his book on Road Building in the United States, General Roy Stone says that "few are aware that, while the construction of the Cumberland Road was in progress, twelve national roads were laid out in the states and territories, making what was regarded then as a complete system of highways, and that more or less work was done in opening and constructing these various highways."

The plank road came into existence as a rival of macadam construction in the year 1835. The first road of this sort to be built in the United States was constructed at Syracuse in 1837. A large number of plank road companies were organized, and within fifteen years from the introduction of that method of road construction 2,106 miles had been constructed in the state of New York. These roads were usually built single track and of planks eight by three inches, laid on stringers resting on more or less well laid foundations. The average cost in New York was less than $2,000 per mile, and their cheapness made them popular. During the period of cheap lumber plank roads were built extensively from the larger cities. Some of them remain, but the gradually increasing cost of lumber has led to other methods of construction. Their usefulness has survived in one respect, however. No community, after once having had a good plank road, could ever go back to the muddy and rutty earth road without strenuous protest.

Paved roadways appear to have received attention in the towns and cities before very much attention was given to the subject of country road building. According to the most authentic records, the first pavements laid in the United States were put down almost simultaneously in the cities of New York and Boston in the year 1650. These pavements have been referred to as pebbles, probably what we would call cobblestone pavements. The development of this branch of road building has been brought to a high state of development—due, of course, to the great amount and diversified nature of the traffic to be accommodated.

The modern awakening to the necessity for better roads, or, as it is more commonly called, the Good Roads Movement, began in 1885, when the bicycle came into general use. Bicycles became very popular, and in consequence a large army of new users of the highways was produced. These wheelmen quickly saw the necessity for better highways, not only for themselves, but for all other road users as well. They organized themselves, and began issuing literature calling attention of the public to the great loss entailed from lack of better country roads. Statistics were published, showing the cost of bad roads to the farmer and to all other citizens. This literature was sent broadcast, and the newspapers were appealed to. The press—always a most potent factor in the molding of public opinion—took the matter up, and public sentiment was aroused.

As a result of the agitation the state of New Jersey put into practical operation a plan for state aid in the improvement of its highways. This was the first application of the principle, and really inaugurated a new era in road building. It is true that as early as 1819 the state of North Carolina gave aid in the construction of roads through a state board of internal improvements. This plan, however, it appears, for some reason, did not work out satisfactorily. The application of state aid in New Jersey was quickly followed by the adoption of similar measures in Massachusetts and Connecticut. The principle thus became well established. It has since been put into operation by other states, so that to-day upwards of 50 per cent. of them have some co-operated plan of road improvement. State aid has now become fully recognized as correct in principle and efficient in its application.

The Office of Public Roads was inaugurated in the year 1893 in the United States Department of Agriculture for the purpose of disseminating information, testing materials, and giving instruction in the art of road building. Statistics compiled and published by this Office in the year 1904 show that at that time there were 2,151,507 miles of roads in the United States. Of this mileage, however, only 153,662 miles were of improved roads, or a little more than 7 per cent. as compared with the total length of all the roads in the country.

The task we have before us of improving the other 93 per cent. of the roads of the country seems gigantic. That we are making progress cannot be denied; that we have not made greater progress is due to many reasons. It must be remembered that it was but a

comparatively short time ago that attention was first seriously drawn to the necessity for road improvement, and that we have but recently placed the country roads under properly organized supervision. The great growth of our population and the consequent increased road traffic, brought about especially by new methods of locomotion, has greatly raised the standard of our requirements. It must, of necessity, take a long time to effectually overcome the neglect and the mistakes of former years. It is not so easy, as road builders know, to make an old, badly constructed roadway over as it is to start and build a new road under modern practice. Road contractors and engineers are not trained in a day to the practical part of the work, and the men who really know how are far too few in number to construct all the roads of this country to meet the conditions of modern traffic as rapidly as many good people would like.

In the great state of Washington a splendid start has been made in road building. No state has shown greater enterprise. No state can dispute her claim to foremost rank in the matter of initiative. The establishment of a Chair of Highway Engineering is a forward step and one well worthy of imitation in every state. In road improvement, Washington has set an example for all this great Western country.

There are two classes in interest in the matter of road building—those who build the roads, or are responsible for their construction, and those who use them. Both classes are represented here to-day, and it is well that they should be. No progress has ever been made without the proper sort of co-operation. There should be a full and complete understanding between these classes. The automobilists, to a man, are good roads enthusiasts; so should be all other users of the highway. Every one who travels a roadway should understand that to make a road suited to present-day conditions requires a thorough knowledge of materials and skill in methods on the part of the road builder. The user should not expect too much. Money is first required, but money will not build roads, unless the men who know how are available. To build faster means larger appropriations and a greater number of skilled contractors and engineers. We must educate road builders; we must train them, before the work can go on at its maximum rate. The men charged with the work of highway improvement are thoroughly honest, conscientious, and efficient, and they are giving the best years of their lives to the public service. Upon them are placed great responsibilities, and they should be given much praise. Their work should not be hindered by those who are too zealous to have all the roads improved in a single day. There are many difficult problems, which must be worked out, and which require time and experience to solve. Education, organization, and administration are the great factors in carrying on the work of road building: let them all be given due attention. It may be true that we are on the eve of great developments in the navigation of the air. With the building of roads above the earth we are not concerned at present. We have

the roads here on earth to-day, and we will have them with us to-morrow. We must rely upon them, and therefore we must make them good. We can do this through unity of action, through enterprise, and through education and organization.

EARTH, SAND, CLAY, AND GRAVEL ROADS.

"Earth, Sand, Clay, and Gravel Roads" was the subject of the paper by **Mr. M. O. Eldredge**, of Washington, D. C.

PAPER BY MAURICE O. ELDREDGE, ASSISTANT IN ROAD MANAGEMENT, U. S. OFFICE OF PUBLIC ROADS.

Earth Roads.

The cost of hauling over country roads is largely determined by the size of the load that can be hauled, the number of trips that can be made in a day, and the wear and tear on teams and equipment. Steep grades, as well as ruts and mudholes, serve to decrease both the speed and the load. On the principle that a chain is no stronger than its weakest links, the maximum load that a team can draw is the load that it can draw up the steepest hill or through the deepest mudhole on that road.

Wherever possible roads should be located on straight lines between terminal points. In hilly or mountainous country, however, the attempts to keep roads straight between terminals often leads to the serious error of heavy grades. Straightness and grade must therefore be handled together. The best location is one which is straight in general direction, is free from steep grades, is located on solid ground, and serves the largest possible number of people.

Roads should be located for the benefit of the people, and not the private landowner. If county officials would apply to each badly located road some simple formula like the following, they would be justified in relocating many roads. For example: The diagonal road on a 160-acre tract is .70 mile and saves .30 mile in going around it. Assuming 3,000 tons of traffic and a cost of 25 cents per ton per mile, the public would save $225 by the short route. This is enough to pay the interest and sinking fund on at least $4,000, which would be sufficient to pay for the whole farm at $25 per acre. The $225 alone would in most cases pay the damage, and in many other cases there would be no damage. If the short road is on a better grade than the long one, the saving would be still greater.

The elimination of one or two steep hills on a line of road will frequently enable horses to draw three or four times as much as they could draw on the old road. It takes approximately four times as much power to draw loads up 10 per cent. grades (10 feet ver-

tical in 100 feet horizontal) as on a level, but on a 4 per cent. or 5 per cent. grade a horse can usually draw (for a short time) as much as he can draw on a level. A 4 per cent. or 5 per cent. grade is, therefore, considered the maximum on roads subject to heavy hauling. Many steep grades may be avoided by locating the road around instead of over the hill, and it is often no further around a hill than over it; the bail of the bucket is no longer when held in a horizontal position than in a vertical. By going around we avoid two steep hills.

If the road must pass up a steep hill or mountain side, the steepness of the grade may be decreased by increasing the length of the road. In other words, eliminate steep grades by locating the road on curved or zigzag lines, and not in a straight line from the bottom to the top of the hill. These curves should be carefully plotted and the straight stretches located with an instrument. This improves the looks of the road and does not add materially to its cost.

In studying the relation of grade to distance, the following calculation is interesting: To lift a ton one foot high requires 2,000 foot pounds of energy; on a road the surface of which offers 100 pounds of tractive resistance per ton the same energy would roll the ton a horizontal distance of 20 feet. To save one foot of grade the road may therefore be lengthened 20 feet.

Roads should never be located so close to stream beds as to be subject to overflow, or on ground which is constantly damp and marshy.

The earth road should have at least six hours of sunshine each day. This can be secured either by locating the road with southern or western exposure, or by having such brush and trees as impede the drying action of the sun and wind removed. With gravel and stone roads, this is not so necessary, as a certain amount of moisture is needed on such roads, especially in the summer time.

Relocating roads is not an engineering problem alone. One must also consider the effect of the road on those who now live upon it. Many farmers dislike to have the road placed back of their houses or out of sight of it. It requires tact and good judgment to secure a suitable location without arousing harsh antagonism.

As soils differ for agricultural purposes, so they differ for roads. Clays or soils of fine texture usually make poor roads, especially if they contain much vegetable matter. The coarser soils, however, which contain some sand or gravel, will often make very satisfactory roads for light traffic, provided they are kept in proper repair.

If the road is composed of fine clay or soil, it will sometimes pay to resurface it with top soil from an adjacent field which has sand or gravel mixed with it. This method, called the "top soil method," is now in successful use in Clarke county, Ga.

The earth road can best be crowned and ditched with a road machine, and not with picks and shovels, scoops and plows. One road machine, with suitable power and operator, will do the work of many men with picks and shovels, and do it better.

The road machine should be used when the soil is damp, so as to make the soil bake when it dries out. If it is worked dry, it takes more power to draw the machine, and, besides, dry earth and dust retain moisture and quickly rut after rains. The use of clods, sods, weeds, or vegetable matter in building earth roads should be avoided, because they also retain moisture.

It is a great mistake to put the working of the earth road off until August or September. The surface is then baked dry and hard. It is not only difficult to work, but is unsatisfactory work when done. Earth which is loose and dry will remain dusty as long as the dry weather lasts, and then turn to mud as soon as the rains begin. By using the road machine in the spring of the year, while the soil is soft and damp, the surface is more easily shaped, and soon packs down into a dry, hard crust, which is less liable to become dusty in summer or muddy in winter.

Storm water should be disposed of quickly before it has time to penetrate deeply into the surface. This can be done by giving the road a crown or slope from the center to the sides. For an earth road which is 24 feet wide, the center should be not less than 6 inches nor more than 12 inches higher than the outer edges of the shoulders. A narrow earth road which is high in the middle will become rutted almost as quickly as one which is too flat, for the reason that on the narrow road all the traffic is forced to use only a narrow strip.

Shoulders are often formed on both sides of the road, which prevent storm water from flowing into side ditches, retaining it in the ruts and softening the roadway. These ruts and shoulders can be entirely eliminated with the road machine or split-log drag.

Ordinarily, the only ditches needed are those made with the road machine, which are wide and shallow. Deep, narrow ditches wash rapidly, especially on steep slopes, which is another good reason for decreasing the steepness of the grades. It is difficult to maintain an earth road, or any kind of road for that matter, on a steep grade.

The width of the earth road will depend on the traffic. As a rule, 25 or 30 feet from ditch to ditch is sufficient, if the road is properly crowned. A road that is narrower than 25 feet is difficult to maintain, for the above-stated reason that on narrow roads the teams are more apt to track than on a wider road, causing it to rut if subjected to heavy hauling.

We should not loosen, dig up, or plow up any more of the surface of an earth road than is absolutely necessary. The road should be gradually raised, not lowered; hardened, not softened.

On flat lands, where water moves slowly, grading material should be taken from the lower ditch, and culverts supplied where waterways occur. A shallow ditch on the upper side makes it possible to give culverts a good fall. Two or more small pipes, instead of one large one of equal capacity, may be used for culverts, especially if the large pipe necessitates much grading or raising of the roadway. At least 6 inches should be left between each pipe, and earth

should be tamped around them thoroughly, so as to prevent a washout.

To prevent washing on steep roads, the water should be carried under the surface at frequent intervals from the upper to the lower side, and from the lower side away from the road. Five 12-inch pipes in a mile of roadway are about as cheap and far better than one 24-inch pipe. The water must be disposed of before it gains force or headway, or has time to damage the road.

If culvert pipes have a fall of 1 inch to 100 feet, the water passing through them has a velocity of about four miles an hour; but if the fall is 36 inches to 100 feet, the velocity is about 20 miles per hour. Hence a pipe laid upon a fall of 36 inches to 100 feet, will have five times the capacity of a pipe of equal diameter laid on a grade of 1 inch to 100 feet. A 24-inch pipe, having a fall of 1 inch to 100 feet, will have a capacity of 3,296 gallons per minute; whereas a 12-inch pipe, having a fall of 36 inches to 100 feet, will have a capacity of 2,554 gallons per minute.

By increasing the fall, we increase the capacity of the pipe, decrease the size of the pipe necessary, and, therefore, decrease the cost of the culverts. Furthermore, culverts laid flat will soon fill up, but if given a good fall they will keep themselves clear.

If much fall is obtained in a culvert pipe, the spillway should be paved. Earth should be tamped under and around the pipe in layers, and should be of sufficient depth to prevent the pipe from being broken by traffic; but under no circumstances should a ridge over the culvert be allowed, for it not only endangers the life of the culvert, but is a menace to traffic.

An attempt to drain mudholes with culvert pipe will fail in most cases. The water should be drained off by means of open ditches, and the soft mud then thrown out and replaced with just enough good firm earth to make it level (after consolidation) with the surrounding surface. If mudholes in earth roads are filled with brush or stone, it usually results in two mudholes, one at each end.

Repairs should be made when needed, and not once a year after crops are "laid by." One hundred days' labor, judiciously distributed throughout the year, will accomplish more and better work in the maintenance of an earth road than the same amount of labor expended in six days, especially if the six days are in August, September, or October, when the ground is hard and dry.

Because of its simplicity, its efficiency, and cheapness, the split-log drag, or some similar device, is destined to come into more and more general use. With the drag properly built and its use well understood, the maintenance of earth and gravel roads becomes a simple and inexpensive matter. Care should be taken to make the log so light that one man can lift it with ease, as a light drag responds more readily to various methods of hitching and the shifting positions of the operator than a heavier one.

The best material for the drag is a dry cedar log, though elm, walnut, box elder, or soft maple are excellent. Oak, hickory, or ash are too heavy. The log should be from seven to ten feet long,

and from eight to ten inches in diameter at the butt end. It should be split carefully as near the center as possible, and the heaviest and best slab chosen for the front. Holes are then bored perpendicular and at right angles to the split faces, and in such a way that one end of the back slab when fastened in position will be about 16 inches nearer the center of the road than the front one. This gives the "set-back," so that the logs will track when drawn along the road at an angle of about 45 degrees. The two halves of the logs are fastened together by stakes, these being mortised into the holes above mentioned. A cleated board is placed between the slabs for the driver to stand on.

A strip of iron placed along the lower face of the front slab will prevent the drag from wearing. The drag may be fastened to the doubletree by means of a trace chain. The chain should be wrapped around the left-hand or rear stake and passed over the front slab. Raising the chain at this end of the slab permits the earth to drift past the face of the drag. The other end of the chain should be passed through a hole in the opposite end of the front slab and held by a pin passed through a link.

For ordinary purposes the hitch should be so made that the unloaded drag will follow the team at an angle of about 45 degrees. The team should be driven with one horse on either side of the right-hand wheel track or rut the full length of the portion to be dragged, and made to return in the same manner over the other half of the roadway. Such treatment will move the earth toward the center of the roadway and raise it gradually above the surrounding level.

The best results have been obtained by dragging roads once each way after each heavy rain. In some cases, however, one dragging every three or four weeks has been found sufficient to keep a road in good condition.

When the soil is moist, but not sticky, the drag does its best work. As the soil in the field will bake if plowed wet, so the road will bake if the drag is used on it when it is wet. If the roadway is full of holes or badly rutted, the drag should be used once when the road is soft and slushy. This is particularly applicable before a cold spell in winter, when it is possible to so prepare the surface that it will freeze smooth.

Not infrequently conditions are met which may be overcome by a slight change in the manner of hitching. Shortening the chain tends to lift the front slab and make the cutting slight, while a longer hitch causes the front slab to sink more deeply into the earth and act on the principle of a plow.

Sand-Clay Roads.

About 1894, an agent of the Office of Public Roads found several miles of natural road near Cape Charles on the sandy shores of Eastern Virginia which were smooth and firm throughout the year. An examination of the surface soil of which the road was composed

developed the fact that the surface contained a mixture of sand and clay. An expert of the office, a few years later, while attending a road convention in Marion county, Fla., found that the road officials of that county were making excellent roads by surfacing the old sandy roads with a natural clay and sand mixture obtained from a pit near Bartow. From these observations, the origin of the sand-clay road may be traced.

Comparatively little, if any, sand-clay road had been constructed previous to 1894; but since that time experts of the Office of Public Roads have been studying and experimenting with this method of construction, and advocating its use, with the result that, ten years after the first observation was made along this line by the Office, there were nearly 3,000 miles of sand-clay roads in the South, distributed as follows:

	Miles
South Carolina	1,575
Georgia	513
North Carolina	438
Florida	435
Alabama	12

At the present time there are probably twice as many miles as in 1904; its popularity being due to the facts that it is cheap, comparatively firm and durable, easy to construct and repair, and that the materials out of which it is built are plentiful in many sections of the country.

The sand-clay road is made by mixing the sand and clay in such a way that the grains of sand touch each other; the spaces between the grains being filled with clay, which acts as a binder.

The approximate mixture of sand and clay may be determined by filling a vessel with a sample of the sand to be used, and another vessel of the same size with water. The water is poured carefully into the sand until it reaches the point of overflowing. The volume of water removed from the second vessel represents approximately the proportion of clay needed.

The proportion of sand and clay can best be determined, however, as the work progresses, as some clay will contain more sand than others. In fact, clays are very frequently found which already contain about the right proportion of sand. This is true of the Bartow clay, above referred to.

The Clay on Sand Road.

If the road to be treated is sandy, the surface is first leveled off and crowned with a road machine, the crown being about one-half inch to the foot from the center to the sides. The clay is then dumped on the surface and carefully spread, so that it will be from 6 inches to 8 inches in depth at the center, and gradually decreasing in depth towards the sides. A layer of clean sand is then usually added, which is thoroughly mixed with the clay, either by traffic or by means of plows and disk or tooth harrows.

The best results have been obtained by thoroughly mixing or

puddling the materials when wet. For this reason it is desirable to do the mixing in wet weather. The mixing can be left to the traffic after the materials have been properly placed; but this involves a whole winter and spring of bad road, and even then the mixing is not always satisfactory. In all cases, it is advisable to dress the road with a road machine or split-log drag after the materials have been thoroughly mixed, and to give it a crown of not more than 1 inch or less than three-fourths of an inch to the foot from the center to the sides. A light coating of sand may then be added. The use of the road machine or drag should be continued at frequent intervals until the surface is smooth and firm.

The Sand on Clay Road.

If the road to be treated is composed of clay, it should first be brought to a rough grade with a road machine. The surface should then be plowed and thoroughly pulverized by harrowing to a depth of about 4 inches, after which it is given a crown or slope of about one-half inch to the foot from the center to the sides. It is then covered with 6 inches to 8 inches of clean, sharp sand, which is spread thicker in the center than at the sides. The materials should then be mixed with plows and harrows while they are comparatively dry, after which they are finally puddled with a harrow during wet weather. If clay works to the surface and the road becomes sticky, more sand should be added.

The road is then shaped, crowned, and ditched in the usual manner with a road machine. This should be done when the surface is soft, yet stiff enough to pack well under the roller or the traffic. Wide, but shallow, ditches should be provided on both sides of the road, and culverts or cross-drains should be placed wherever water flows across the road, for it is exceedingly important that the "sand on clay" roads be well drained.

After the "clay on sand" or the "sand on clay" road is completed, it should be carefully maintained until the surface becomes firm and smooth. The construction of this type of road is by no means a quick operation. If soft, sticky places appear, more sand should be added, and if loose, sandy places are found, more clay is needed. It is just as important to attend to these small details as to any other part of the work; for, if they are neglected, the road is liable to fail.

It requires approximately one cubic yard of clay to surface 1½ running yards of road 12 feet in width, or about 1,175 cubic yards to the mile. From three-fourths to one cubic yard will make a load for two horses on a dry clay road. The cost of the road will therefore depend largely upon the distance the material is hauled, the average being from $300 to $800 per mile. A road built under the direction of the Office of Public Roads at Gainesville, Fla., one mile long, 14 feet wide, and having 9 inches of sand-clay surface, cost $881 per mile, or 10 cents per square yard. Another sand-clay road built by the Office at Tallahassee, Fla., 16 feet wide, 7 inches thick, cost $470 per mile, or about 5 cents per square yard.

Gravel Roads.

A properly located and well-drained earth foundation is the prerequisite of a good gravel road. It is a waste of material and labor to apply gravel to the surface of a road which is full of ruts and holes. A smooth, solid foundation is just as necessary as in macadam construction.

There are so many different kinds of gravel that it is almost impossible to lay down principles of construction which will hold good in all cases. A road building gravel should bind well. The qualities of hardness and toughness are important, but not so important as the cementing value. The angular gravels, with square, sharp fractures, are the best. Water-worn creek or river gravel, which is round and clean, will seldom produce a satisfactory wearing surface. Such material may, however, be used for a foundation, and bonded with a layer of suitable pit gravel.

Two deposits of gravel are seldom found which are exactly alike. When there are several pits to choose from, hand samples should be selected from each and carefully examined, and if possible a test made to ascertain the cementing value of each. By separating the gravel, sand, and clay a fair idea of the relative value of each may be ascertained. If there is still any doubt as to which is the best, a short stretch of road built of each sample will indicate, within a few months, not only the cementing value, but also the wearing quality, of each.

If the gravel varies in size from very small pieces to large pieces, good results may sometimes be secured by separating the gravel with a hand or power screen. Gravel roads built of screened gravel are usually superior to those built of unscreened gravel, although there are exceptions to this rule.

When the gravel is separated, the larger sized pieces are used for the foundation, the medium sized pieces for the wearing course, and the smaller pieces and dust for the binder, as in regular macadam construction. If there is an excess of earth, sand, or clay, as is often the case, these can and should be removed by screening.

An outfit consisting of a gasoline engine, hopper, elevator, revolving screen, and medium size bins for three sizes of gravel will cost in the neighborhood of $1,200. For a small additional outlay a drum and cable may be attached to the engine with which to operate a bucket conveyor to carry the gravel from the pit to the hopper.

A platform built around the mouth of the hopper, with inclined wings so arranged that the teams may drive on and off the platform, will make it possible to deliver the gravel to the hopper with drag or wheel scrapers. A similar platform, with trap doors and sufficient space beneath for wagons to pass under it, is useful in pits where it is not necessary to screen the gravel. With such a platform, wheel and drag scrapers may be used in delivering the material from the pit to the platform, from which it is dumped automatically through the trapdoors to the wagons beneath.

There are many different methods of building gravel roads in use in various parts of the country. Most of them, however, are built without method or plan. Some fail because the material is poor, but the majority of the failures is due to the fact that the material is not properly applied to the surface.

The following are the principal causes of failure. First: Poor material; round, water-worn gravel; too little binder or too much sand, earth, or clay. Second: Unstable foundations; placing gravel on surfaces filled with ruts and holes. Third: Poor drainage; too flat, or too high in the middle; side ditches too deep or not deep enough; culverts which are too small, or which are laid so flat that they are soon filled with silt or trash. Fourth: Spreading gravel in dry weather; dumping it in piles and leaving it for the traffic to spread. Fifth: Making the road too narrow to accommodate the traffic, or so narrow that wagons will track and soon cut the surface into ruts. Sixth: Failure to keep ruts and holes filled with *gravel.*

With good binding or cementing gravel satisfactory roads may be made by surfacing the prepared earth subgrade with one or two layers of this material. The earth road is first shaped with a road machine, and, if possible, rolled with an 8 or 10 ton roller. The earth foundation should be crowned but slightly. The material is spread in one, two, or three layers to a total depth of from 8 to 10 inches in the center and from 4 to 6 inches at the sides, gradually diminishing in depth to a feather edge toward the side ditches. The depth of gravel will depend upon the traffic, and to some extent on the material, as well as the earth subgrade.

If the material is spread in layers, then the coarser grade is placed for the foundation, and the finer grade for the wearing surface. In case screened gravel is used, the larger size pieces, those which will not pass a three-inch ring, should be thrown out or raked into the foundation course as the work progresses.

Some varieties of gravel must be sprinkled and rolled before they will consolidate, while others bind well under ordinary traffic. Sometimes a good practice is to apply the gravel in wet weather, or to wet the gravel before it is applied to the road. In some cases a little clay or loam will hasten the binding process. Care should be taken, however, not to use too much clay or loam, as these will soften in wet weather. An excess of clay makes the road dusty in summer and muddy in winter.

If it becomes necessary to build the road without a roller or sprinkler, the work should be done in the spring of the year before the rains have ceased. The traffic will pack the material much better then than in the summer or fall. The road machine or split-log drag may be used to advantage in removing ruts and filling holes while the road is green. A little attention while the road is green is better than much attention later, on the principle that an ounce of prevention is worth a pound of cure.

The width of the gravel road will depend upon traffic conditions. It should be surfaced to a width of at least 12 feet, and, if possible, to a width of from 14 to 16 feet. A narrow strip of gravel

will wear out much more quickly than one which is a little wider. If the road is surfaced to a width of 16 feet, then the crown ought to be from 6 to 8 inches from the center to the outside edge of the gravel. This is sufficient for drainage. If the crown is higher than about an inch to the foot, the traffic will be forced to the center of the road and cause it to wear more quickly.

Gravel roads are often built in the same manner as macadam roads; that is, the foundation is provided with shoulders and the material is spread in two or three layers of uniform thickness from center to sides. This method can be used to advantage where gravel is scarce, as the shoulders are composed of earth instead of gravel.

In case gravel fails to bind or wear well, good results have been obtained by applying to the surface a thin layer of crushed rock screening, preferably trap. Several miles of the gravel roads in Rock Creek Park, Washington, D. C., are treated in this way. They look like macadam roads, and wear almost as well, but are very much cheaper.

The suggestions as to drainage and culverts given in the paper on earth roads also apply to gravel roads.

The split-log drag has been used with great success in maintaining gravel roads. There is a tendency on most gravel roads for the material to work toward the sides, forming shoulders, which prevent water from reaching the side ditches. The standing water thus held back softens the foundation, causing the surface to give way into ruts and holes. If the road is rolling, these shoulders sometimes cause the water to follow the wheel tracks and wash the surface into deep gullies. An occasional dragging will *prevent the formation of such shoulders.*

The gravel road ought to have a little attention throughout the year, instead of a great deal of attention at one time. One hundred days' labor, distributed throughout the year, applied on say 5 miles of gravel road, will keep it in much better condition than the same amount of labor applied in a day or a week.

No one who has observed the results will fill mudholes in gravel roads, or any kind of road for that matter, with large rocks or boulders, yet there are probably more mudholes filled in this way than with gravel. After the mud has been removed, the holes should be filled with the same kind of gravel as that with which the road is surfaced.

When the gravel is worked with a road machine, the sods and weeds are often left in windrows in the middle. These should be raked up and thrown into the adjacent field, or otherwise disposed of, as they retain moisture and cause lumps and holes if left on the road.

The cost of building gravel roads varies greatly in different parts of the country, depending principally on the distance material is hauled and the cost of labor and teams. So far as can be ascertained, the average cost of building 19,900 miles of gravel road in Indiana was $1,473 per mile. The average cost of building 237

miles of gravel roads in New Jersey was $2,425 per mile. The New Jersey roads were surfaced to an average width of 15.3 feet and an average depth of 8.4 inches. The average cost of building 70 miles in Connecticut was $3,741 per mile. The Connecticut roads were surfaced to an average width of 15.5 feet and to a depth of 8.3 inches.

From these figures it appears that gravel roads in Connecticut cost about twice as much as the gravel roads of Indiana. A closer scrutiny of the Indiana figures, however, reveals the fact that the cost in that state varies from $300 to $3,500 per mile. Most of the gravel roads in Indiana are built by the farmers in working out their taxes, which is not a very satisfactory method of road building. The material is usually spread on the rough, unprepared surface to a depth of from 8 to 12 inches and to a width of from 9 to 14 feet, and is then left for traffic to spread and consolidate. The gravel roads of Connecticut, however, are built under the direction of the State Highway Commissioner, who is an experienced highway engineer. The material is well selected, spread on a prepared foundation, and properly consolidated. While Connecticut gravel roads may cost twice as much as those of Indiana, they are undoubtedly twice as good and are worth what they cost.

The average cost of maintenance will vary as much as the cost of construction, and will depend, not only on the quality of material used, but also on the method of construction as well as the volume of traffic. The average cost of maintaining 19,900 miles of gravel road in Indiana, which had been built over five years, was about $90 per mile per annum.

While the original cost of stone roads per mile in Indiana was nearly doubly the cost of gravel roads, the cost of maintenance per mile per annum was about one-half. If the original cost of construction is added to the cost of maintenance for 20 years, it will be seen that Indiana gravel roads have cost about as much as the stone roads. The facts emphasize the importance of testing the relative wearing quality of all available materials before large amounts of money are expended in road building.

CREOSOTED WOOD BLOCK STREET PAVING.

"Wood Block Pavements" was the subject allotted to **Mr. Andrew Rinker,** of Minnesota, after which the delegates adjourned for lunch.

PAPER BY ANDREW RINKER.

In preparing this paper, I shall not attempt to cover the subject of Street Paving generally, but confine it more particularly to the Creosoted Wood Block Street Paving as relates to our investigations of the subject and the experience obtained by its adoption

and use in the city of Minneapolis during the past eight years—1902 to 1909, inclusive.

The first of what might be termed the Modern Creosoted Wood Block Street Pavement was laid in this city during the season of 1902 on Tenth Street South, at that time considered a residence street, although, after being paved, developed into a street of considerable heavy traffic. At that time very little paving of this character had been laid in the United States, and our means of determining its relative merits as to durability, desirability, cost, etc., with that of other kinds of pavement, were rather limited. Indianapolis, which was practically the "pioneer city" in its adoption, had some of it. A small portion of Michigan Boulevard, in front of the Auditorium Hotel, and the Rush Street Bridge, in Chicago, were paved with it, practically for experimental purposes. The treatment of the Indianapolis blocks for the first few years after the adoption of the creosoted block paving consisted only of a dipping or natural absorption process; there being no pressure used to increase penetration of oil, and the timber used being Washington red cedar.

The writer is informed that the photographs that have been given wide circulation throughout the country, showing a buckling of the so-called creosoted block paving in that city, due to expansion and contraction, is practically all of the dipped block variety; that the pavement laid during more recent years, treated under the vacuum and pressure method with from 12 to 16 pounds of oil to the cubic foot, do not show such conditions; and that the photographs are unfair representations of the up-to-date creosote paving in Indianapolis.

The first pavement of this character laid in Minneapolis (that on Tenth Street South) is a long long-leaf Georgia pine block, with a treatment of about 12 pounds of oil per cubic foot. This pavement has now had seven years' wear and shows very little deterioration. No repairs due to traffic conditions have been necessary, and, if we can judge as to its lasting qualities from its present appearance, it will still be in good condition at the end of an additional seven-year period.

After 1902 the blocks used were principally Norway pine, with some tamarack. The city council adopted the Norway pine block for two reasons: One, that it was less expensive; the other, it was practically a local product, consisting of Minnesota and Wisconsin timber. It was also assumed that the cheaper and softer kinds of timber would give satisfactory results after treatment. It was on this theory that the United States Department of Agriculture, Forest Service, entered into negotiations with the city of Minneapolis and two of the creosoting companies to lay an experimental pavement in Minneapolis (as described in Circular No. 141 of the United States Agriculture Department). It might be well to state at this time that the department named has been severely criticised by parties interested in other kinds of street paving, on account of the publication of Circular No. 141, assuming that the Department of

Agriculture had no right to exploit the creosote wood pavement as against other kinds. This seems to be an unjust criticism, as our understanding with the Forestry Bureau was that the experiments were to be made for the purpose of determining the relative merits of different kinds of wood, and whether the cheaper and softer woods, after treatment, would not prove satisfactory. This, undoubtedly, was the writer's understanding of the object sought in making the experiment.

As to this particular experimental pavement: During the remaining 5 months of 1906 (August to December, inclusive) after the pavement was laid, and during the entire 12 months of 1907, records of travel were taken twice each month, and during the year 1908, once each month, all of them for 12-hour periods, from 6 a. m. to 6 p. m. The tonnage included weight of horses and vehicles. A plan of Nicollet avenue roadway, showing the location, extent, and kind of blocks used, together with a tabulated statement of the record of travel on the experimental pavement are hereto attached. Where the letters "S" and "W" appear in the table, the traffic consisted of sleds and wagons, as the pavement was covered with ice and snow during a portion of each winter. Owing to the fact that this experimental pavement has been in use less than three years, the writer does not feel warranted in concluding that the portions of it that appear to be in the best condition at the present time will continue to show the best results at the end of a period of 10 or 15 years. Its present condition, however, shows a preference for wood in the following order, viz.: Southern pine, Norway pine, tamarack, white birch, hemlock, Western larch, and red fir. Our experience leads us to believe that the streets should be classified as to traffic, and for the heaviest, such as Nicollet avenue, the long leaf Georgia pine gives the best results; for a medium heavy or light traffic, the Norway pine, tamarack, birch, or hemlock would give good results. Much depends, however, on the proper selection of any of the timber used, as the slower growth, with not less than twelve rings to the inch, is better than the more rapid growth timber of the same kind. As to the Douglas fir, while our experiment does not prove satisfactory, it may be due largely to the fact that it is of the quick growth variety. Had it been a slower growth, closer fibered fir, the results would doubtless have been as satisfactory as that of the Norway pine, tamarack, or hemlock.

Concerning the experience of Minneapolis, generally speaking, the creosoted wood block paving has proven satisfactory, not only from an engineering point of view, but also from that of the property owner and taxpayer, who has it to pay for.

Our city charter and ordinances do not require the city authorities to pave a street with such material as the owners of a larger part of the abutting property may petition for or desire, yet during the past three years the desire of a very large majority of such owners has been to have their streets paved with creosoted block pavement, even at a greater cost than that of other kinds. During the past four years, including 1909 orders, the percentage of creo-

soted block paving laid, as compared with all other kinds is as follows, viz.:

Year 1906....................	Creosoted block,	54½%.	All other kinds,	45%.
Year 1907....................	"	58%.	"	42%.
Year 1908....................	"	77%.	"	23%.
Year 1909....................	"	75%.	"	25%.

The advantages in the adoption and use of this kind of pavement are that it is, comparatively speaking, a noiseless pavement, it is easily kept clean, the wear and tear on horses and vehicles is reduced to a minimum, it is antiseptic (on account of its impregnation with creosote oil), and its traction resistance is slight.

Some of the objections that we hear against it are that, if properly laid with hard woods it becomes slippery, and that it buckles or heaves on account of expansion. As to these arguments, the writer's experience in connection with the laying of nearly half a million square yards of it during the past six years is a sufficient justification for the statement that such conditions are not common in Minneapolis; that, when this kind of pavement is slippery, it is due to weather conditions (sleet and glare ice), that have the same effect on other kinds of street pavements; and the only raising of blocks from their beds is along the rails of street railway tracks, where water has penetrated and frozen. This latter condition prevails to a limited extent, and by proper methods of construction can be entirely avoided.

The diagram showing in miles the different kinds of street pavements in the city of Minneapolis for each year, calculated on a basis of 27 feet average width of roadway, together with the traffic tables and plan heretofore referred to and hereto appended, are taken from the annual reports and the official records of the City Engineer.

The specifications hereto attached are for blocks delivered f. o. b. cars in the city of Minneapolis, at points as convenient as possible to the streets to be paved; the city unloading and delivering the blocks.

The city of Minneapolis does its own work of grading, putting in the concrete foundation, and laying the blocks, by day labor and not by contract.

The prices of labor, teams, etc., are as follows, viz.:

Day of Eight Hours.

Teams, $4.00 (50 cents per hour), per day.
Superintendent, $5.00 per day.
Foreman, $3.50 and $4.00 per day.
Engineer of steam roller, $3.60 per day.
Block layers, $2.50 per day.
Common laborers, $2.00 per day.
Bed man, $3.00 per day.

In addition to the above, we have a chemist at the treating plant, who is paid $3.00 per day every day (including Sundays and holidays) during the season. Receiving clerks, who receive materials, are paid $3.00 per day for each day they work.

Specifications for Creosoted Wood Paving Blocks, Minneapolis, Minn. 190—.

Approximate quantity, ——— square yards or any part thereof.

Section No. 1. Work to be Done. The work to be done under these specifications is the furnishing and delivering, f. o. b. cars Minneapolis, creosoted wood paving blocks to be used in paving during the season of 190—.

Section No. 2. Kind, Size, and Quality of Blocks. The blocks to be furnished must be 4 inches in depth (parallel to the fiber) 4 inches in width and 5 inches to 10 inches in length, but must average 8 inches in length. They shall be perfectly rectangular, of a uniform depth and thickness, free from excessive sap wood, rot, cracks, checks, worm or knot holes, or other injurious defects affecting the life of the block or the laying of the same, and shall be made of sufficiently dry and well seasoned material to admit of proper treatment, as hereinafter specified. The blocks may be either long leaf, yellow or Georgia pine, Norway pine, or tamarack, but all blocks on any one piece of work shall be of the same kind of timber. No second growth timber will be accepted. Reasonable allowances to be made for saw cuts and shrinkage in above-mentioned sizes.

Section No. 3. Quality, Treatment. The blocks shall be so treated that the pores of the wood shall be entirely impregnated with the creosoting material, making it impervious to water and preventing decay.

Section No. 4. Oil, Analysis, Distillation. The oil to be used in the treatment of the blocks shall be a pure heavy creosote oil, obtained from the distillation of coal tar, only, and of the following quality:

(a) The specific gravity of the oil shall be at least 1.12 at a temperature of 20 degrees centigrade.

(b) It shall be completely liquid at 25 degrees centigrade and show no deposit on cooling to 22 degrees centigrade.

(c) It shall not contain more than 3% of matter insoluble in benzine.

(d) It shall be subjected to a distillation test, as specified below, and shall conform to the following requirements: 100 grains of oil shall be placed in an 8 oz. retort, fitted with a thermometer, the bottom of the bulb of which shall be placed ½ inch above the oil and not moved during the test. The discharge opening of the retort shall be from 20 to 24 inches from the bulb of the thermometer and the retort shall be covered so as to prevent too rapid radiation. The percentages are for dry oil and by weight. The average of a number of tests shall show a mean of these percentages.

Up to 150 degrees centigrade, nothing must come off.

"	171	"	0% to 0.5%.
"	210	"	3% to 6%.
"	235	"	10% to 20%.
"	315	"	35% to 45%.
"	355	"	45% to 55%.

The distillation shall be gradual, and up to 315 degrees centigrade should be completed in 30 minutes from the first drop, and should be fully completed in 40 minutes. Thermometer readings to be corrected for emergent stem.

(e) In the process of treatment of the blocks, not more than 2% of water will be allowed. The distillate from 170 degrees to 210 degrees centigrade, will be approximately tar acids, and from 210 to 235 degrees centigrade, will be approximately napthaline.

Section No. 5. Impregnation. After the blocks shall have been made of the specified kind of material and all the defective blocks have been removed, they shall be placed in an air-tight chamber, where by the use of heat and vacuum, all of the sap and moisture shall be removed. The vacuum shall be from 20 to 26 inches and the heat shall not be carried to such an extent as to injure, in any manner, the fiber of the blocks. While the chamber is under vacuum, the creosoting mixture, of the quality as before specified, and heated to a proper temperature, shall be admitted and pressure added until at least 100 pounds per square inch is reached and maintained, until the blocks have absorbed at least 16 pounds of the mixture for each cubic foot of timber, and until the creosoting mixture shall have entirely impregnated all parts of each and every block. The contractor may use any practicable and approved method of treatment, but the results must be the same, viz., putting into each cubic foot of wood 16 pounds of the oil as above specified, without injury to the fiber of the wood.

Section No. 6. Delivery. The blocks shall be furnished in such quantities and at such times as the city engineer may direct, and, if so directed, the contractor shall furnish 1,000 square yards per day. Any extra cost or damage occurring by the failure of the contractor to deliver the blocks as ordered by the city engineer shall be charged to the contractor and deducted from any moneys due, or that may become due, said contractor.

Section No. 7. Inspection. All blocks, material, oils, and labor, shall be subject to the inspection of the city engineer and shall be done to his entire satisfaction and approval. The contractor shall furnish all the facilities for the proper inspection of all such material and the measurement of the same. If the blocks shall be made outside of the city of Minneapolis, the contractor shall pay all the legitimate expenses, salary excepted, caused by the placing and keeping of an inspector at the plant; and the price bid shall include all such expenses.

Section No. 8. Final Inspection; Rejection. Final inspection of the blocks will be made on the street, and any blocks rejected shall be removed by the contractor, at his own expense. If such rejected blocks are not removed within five days after due notice by the city engineer, then the said city engineer shall cause said rejected blocks to be removed, and any cost or expense of such removal shall be deducted from any moneys due, or that may become due, the contractor.

Section No. 9. Proposals. Bidders, in their proposals, will state a price per square yard, street measurement, for the kind of creosote blocks they propose to furnish.

Section No. 10. Specials. If, on account of any paving along the rails of the street railway track, it will become necessary to use a special block, or to use a filling strip under the head of the rail, the contractor will state a price per square yard for such special block or a price per lineal foot for a creosoted pine board 1⅛ inch by 2½ inches.

Section No. 11. City Treasurer's Receipt. A city treasurer's receipt, showing the deposit of the sum of $———, conditioned upon the execution of the contract, within ten days after the award of the same, must accompany each proposal.

Section No. 12. Bond. A bond in the full amount of the contract for the use of the city of Minneapolis, and of all persons doing work or furnishing skill, tools, machinery, or material, under or for the purpose of such contract, conditioned according to section No. 4335, Revised Laws of Minnesota for 1905, and for the full and satisfactory completion of the contract and to indemnify the city of Minneapolis from any damage that may arise on account of any negligence on the part of the contractor, or his

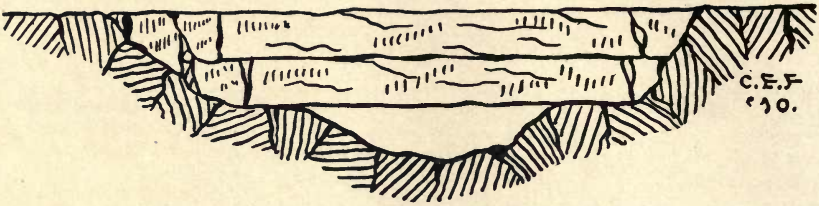

FIGURE 1. EGYPTIAN STONE BEAM BRIDGE.

FIGURE 2.

BABYLONIAN ARCH OF BRICK AT NIPPUR.

FIGURE 6.

MILL CREEK SUSPENSION BRIDGE.

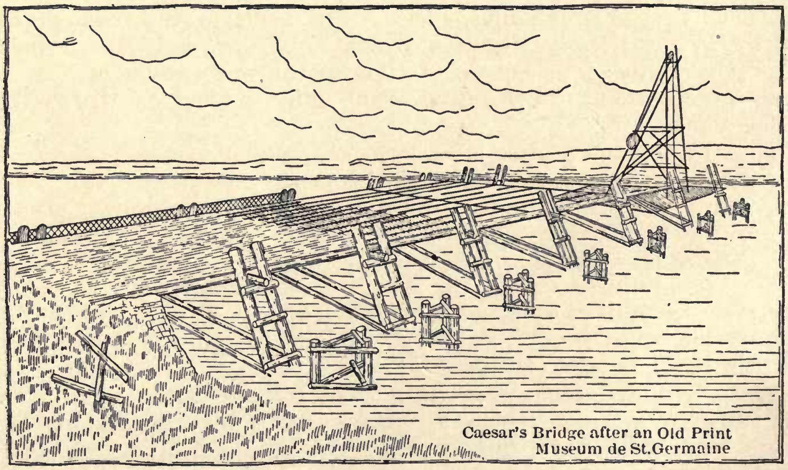

FIGURE 3. CAESAR'S BRIDGE.

employés, and the payment of all just claims, will be required of the contractor at the time of the execution of the contract. The bond to be approved by the proper city officers, signing and countersigning the contract.

Section No. 13. Payments.

The work will be paid for on monthly estimates of the city engineer, reserving 10% until the final completion of the work.

Section No. 14. Acceptance and Rejection of Bids.

The city of Minneapolis reserves the right to accept or reject any or all bids or any portion of any bid.

AFTERNOON SESSION, AT 2:00 P.M.

BRIDGES OF STONE, CONCRETE, AND STEEL.

Mr. Charles Evan Fowler, of Seattle, gave an interesting lecture on Bridges, illustrated with stereopticon views of many famous structures in the United States and Europe. His paper is given herewith.

PAPER BY CHARLES EVAN FOWLER, M. AM. SOC. C. E., M. CAN. SOC. C. E.

The construction of bridges for carrying traffic across streams dates back to early historical times, and it is also true that natural and primitive bridges were used before history was recorded; the earliest types being the fallen log and the hanging vines, which were used by our Darwinian ancestors as a means of crossing the rivers. The earliest structures which could properly be termed bridges were the stone beams, similar to the one shown in Fig. 1, which were used by the Egyptians and other ancients for crossing small gulches.

The earliest known arch (Fig. 2) is one which was discovered in the ruins of Babylon, and which dates back to about the year 4000 B. C. This was doubtless the prototype of the old masonry Persian bridges, most of which had arches of Gothic outline. The Chinese have used stone arches for many thousands of years, and the Japanese were doubtless among the first to use structures of the cantilever type, such as the bridge in the province of Etchin, Japan. A curious type of structure, partly cantilever and partly suspension, constructed of bamboo, is used in Java.

Cæsar's bridge across the Rhine, one of the most famous of early structures (Fig. 3), was nothing more than a pile bridge, while Trajan's famous bridge was a very great advance over this, being a more permanent type of timber arched spans.

In connection with the wonderful highways built by the Romans in the various parts of the Roman Empire, stone bridges were constructed, many of which are in use to this day; the well-known bridge of Augustus being a splendid example of the solid construction employed.

The first truss bridge was probably a simple structure, consisting of no more than two members, forming an "A" truss, or simply of rafters, such as were used in buildings. The evolution of the modern truss bridge from this can be readily traced, and the many early truss bridges constructed of timber in the United States represent the greatest development of this class of structures, until metal began to be used. The wooden bowstring arch over the Scioto river at Chillicothe, Ohio (Fig. 4), is a splendid example of the thorough way in which these bridges were built; this one having lasted for 70 years, or until it was replaced by a modern steel bridge.

Modern roadway bridges are of various types, consisting of simple girders or culvert arches over small streams or openings; girder spans and arches of various materials for medium sized openings, and truss spans, arches, and suspension bridges for greater lengths. In many instances viaducts are employed, where ravines, valleys, or cañons are to be crossed, the simplest of which is the familiar timber trestle of piling or frame bents. Where a more lasting structure is required, steel viaducts are used, or viaducts built of arched construction in which steel, stone, and concrete are employed.

Modern roadway bridges should be constructed, not only with reference to their engineering features, but also as works of architecture. Where the spans are short, and girders or simple arches used, but little attempt can be made toward the artistic; but the small stone arch (Fig. 5) constructed in Mill Creek Park, Youngstown, Ohio, gives an idea of what may be done, even for very short spans, in making them pleasing, as well as answering the demands of traffic. Some of the smaller bridges of Japan and China, suitable only for passengers, are very ornamental, similar to the famous Camel-Back bridge in China.

When spans are so short that it is not economical to use either steel girders or arches, stone beams similar to the primitive ones already spoken of may be used, or the modern type of reinforced concrete can be employed, carrying ornamental balustrades.

Girders of somewhat longer span may also be constructed of reinforced concrete, and the same materials used in constructing short arches, which can be made as ornamental as desired or as is possible with the funds available. The 90-foot steel arch (Fig. 6) and a 90-foot steel eye-bar suspension built by the author in Mill Creek Park, Youngstown, Ohio, are examples of what can be done to make structures of this size ornamental.

Where it is necessary to have through or overhead bridges to avoid obstructing the waterway, structures similar to the steel bridge constructed by the writer over the Scioto river in Ohio (Fig. 7), of two spans of 240 feet each, may be used, and the portals and bracing overhead made of solid and ornamental construction. A similar

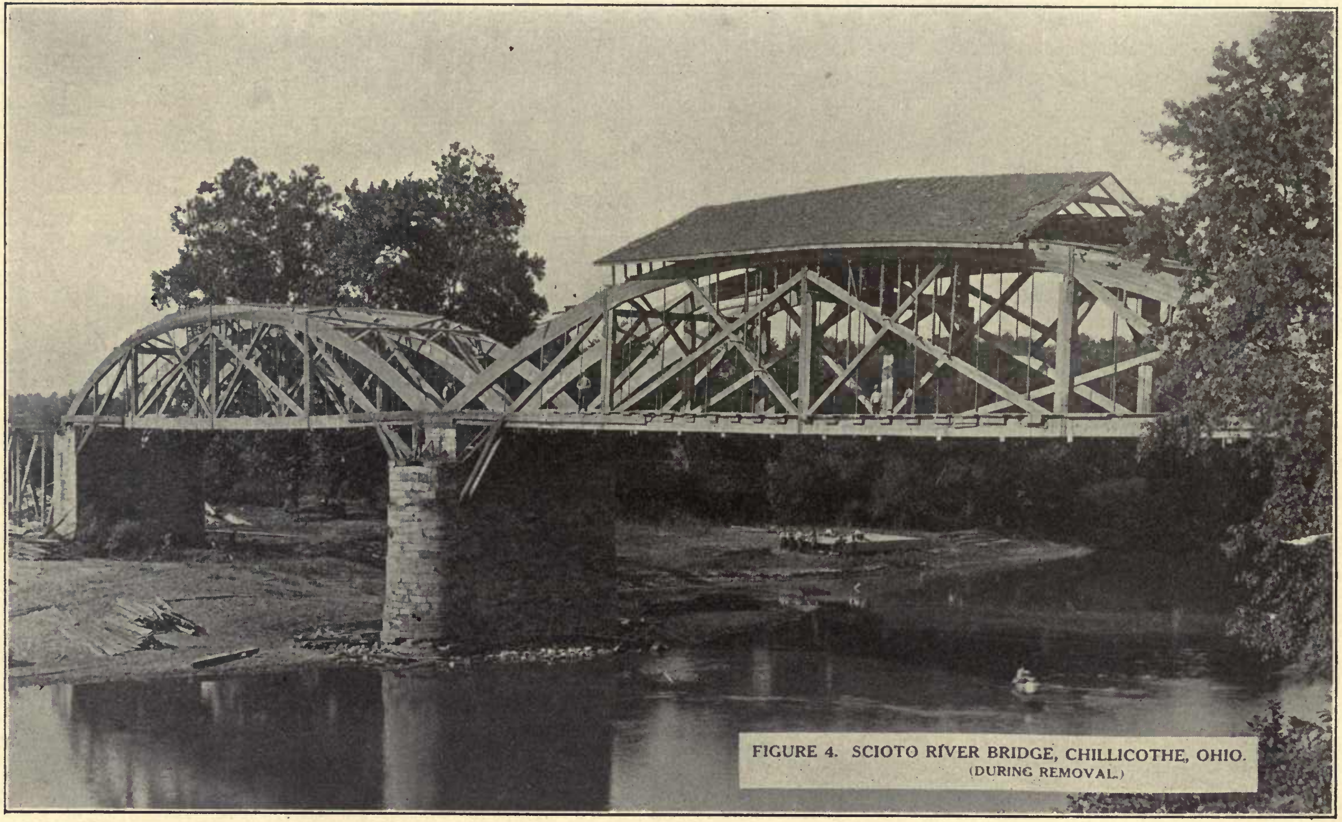

FIGURE 4. SCIOTO RIVER BRIDGE, CHILLICOTHE, OHIO.
(DURING REMOVAL.)

FIGURE 5. MILL CREEK PARK, YOUNGSTOWN, OHIO.

FIGURE 7. SCIOTO RIVER STEEL BRIDGE.

FIGURE 8. ARCHED CANTILEVER, KNOXVILLE, TENN.

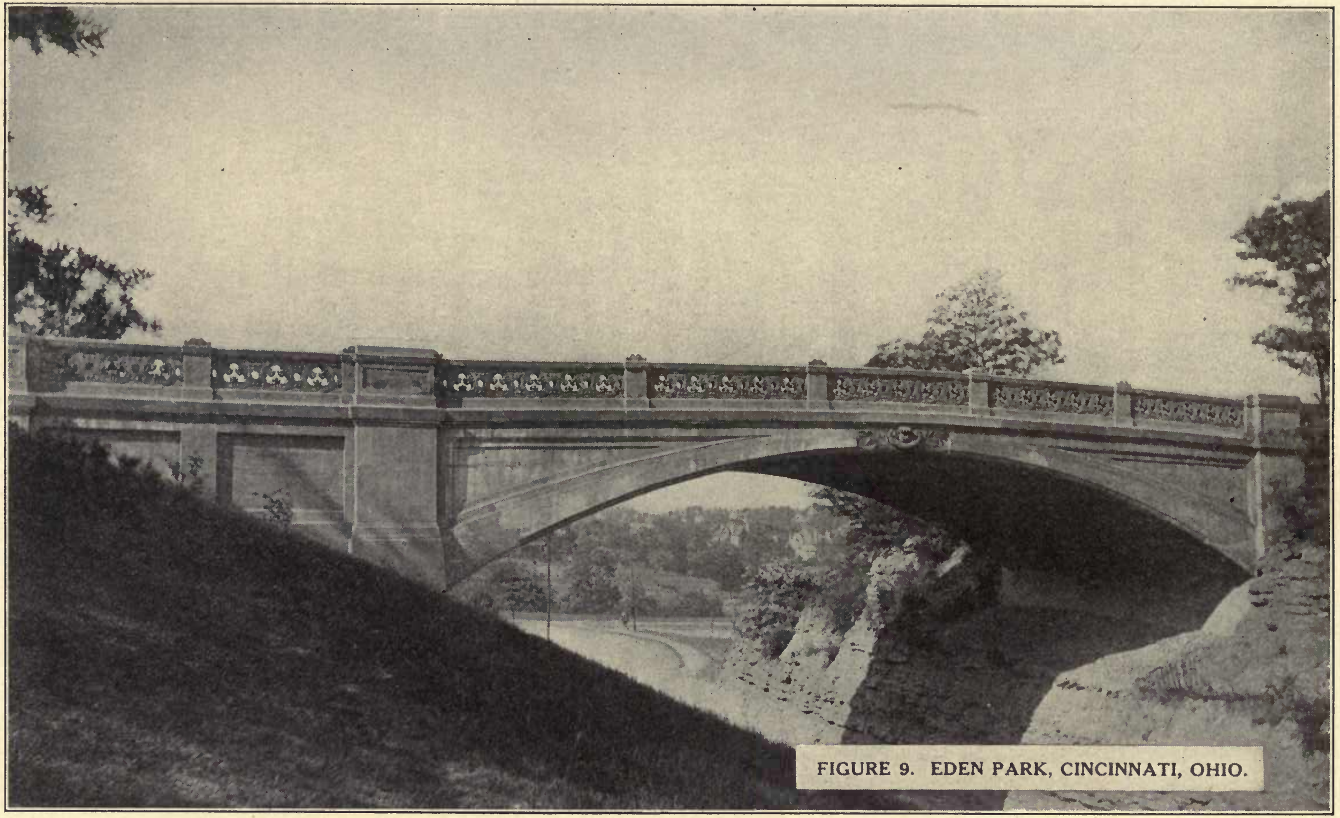

FIGURE 9. EDEN PARK, CINCINNATI, OHIO.

type of bridge may be seen in the Spring Common span of 175 feet in length at Youngstown, Ohio, which follows closely the European type of through roadway structures.

Where there is sufficient waterway or height above the stream, it is advisable for architectural effect to employ arches and make the structures truly ornamental. The earliest use of metal for an arch of this kind is the one built at Coalbrookdale, in England, in 1777, with a span of 100 feet and 6 inches. A modern structure of this type is the Market Street two-hinged plate girder arch at Youngstown, Ohio, with a span of 210 feet and a rise of 60 feet. This arch supports a paved roadway 40 feet in width and two sidewalks of 10 feet each. The finest example in the world of this kind of a bridge is the famous Washington Bridge over the Harlem River in New York City. The two main spans are steel plate girder two-hinged arches, each 508 feet center to center of piers. The approaches, piers, parapets, and balustrades are of the most elegant design.

Where there are several spans and sufficient height, a series of arches may be employed, as was done by the writer at Knoxville, Tenn., where a stone bridge was proposed, but steel finally employed, on account of the expenditure necessary for the stone bridge being too great. The Knoxville bridge (Fig. 8) is of the arched cantilever type, and, with the exception of not being quite as stiff for traffic, answers the requirements in an artistic sense as well as a bridge of true arches would have done. It is a symmetrical structure, harmonious, and complies with the fundamental artistic requirement of having an odd number of spans; an opening at the center being more pleasing in an æsthetic sense. The design of the proposed stone bridge, on the other hand, was for an unsymmetrical structure with an even number of spans, and, while a striking design, was one which could have been very easily improved upon.

The use of reinforced concrete for arch bridges is one of the greatest advances that has been made in engineering, as it makes possible the construction of artistic masonry structures at a comparatively reasonable cost, or at very little, if any, excess in cost over first-class steel structures on masonry piers.

The arched span in Eden Park, Cincinnati, Ohio (Fig. 9) while of only moderate length, is one of the most beautiful and effective designs that has been built anywhere in the United States. The construction is upon the Melan system, and is one of the first of this kind to be constructed in this country.

Another beautiful bridge of reinforced concrete is the two-span structure at Reno, Nev., which is more simple in design, but also very pleasing.

The bridge at Niagara, above the Falls, is of reinforced concrete faced with stone, and, while this is hardly to be defended from the standpoint of truthful architecture, inasmuch as it does not tell a true story of the construction, it is a very pleasing piece of work.

Nowhere else in the world has the art of bridge building reached such a state of perfection as in France, and the bridges of Paris

are, most of them, remarkable structures and worthy of careful study. The most famous of these is the Pont Neuf, which was commenced in 1578, during the reign of Henry III, but was not completed until the year 1607. The spans are comparatively short, ranging from 31 to 62 feet in length, but the masonry is of the most solid type and very chaste design. The width of the bridge is 72 feet, and it is virtually a street carried across the river.

Many of the bridges in Paris and in France were constructed by Napoleon, there having been expended between the years 1804 and 1813 nearly forty million francs for bridges alone; the bridge of Austerlitz costing three million francs. This was built to commemorate Napoleon's victory of the same name, and the structure is one of the most beautiful pieces of bridge architecture in existence, having, to begin with, five, or an unequal number, of spans, with details of the most pleasing character and satisfactory in every way.

The Chester-Dee bridge, with a span of 200 feet and a rise of 42 feet, located at Chester, England, is one of the most notable stone bridges in the world. While a very long span for a stone bridge and of the most solid and careful construction, the design is very much marred by the paneling of the spandrels, which dwarfs the apparent size of the structure and is not at all applicable to a large bridge.

The Luxembourg Arch was, at the time of its construction, the longest stone span that had even been built in the world; the length being 275.5 feet (Fig. 10). The design is a beautiful one, with very elegant and appropriate details, and the lines and effect of the entire design are greatly enhanced by the arched spandrels carrying the roadway.

The Connecticut Avenue bridge in Washington, D. C. (Fig. 11), is another notable roadway bridge, not only on account of its beautiful design, but on account of the fact that it is of solid concrete construction without reinforcement, and without stone facing or stone ornamentation of any kind.

Whenever funds are available, as much ornamentation of the structure and of the entrances to it should be employed as is appropriate. Many of the bridges constructed by the Romans had entrance arches at either one or both ends, which were beautiful pieces of architectural work and very appropriate. One of the oldest of these was the bridge at St. Chamas, with an arch or portal at each end of a classic design.

The Elizabeth bridge over the Danube at Budapest is one of the handsomest of modern European bridges, being constructed with eye-bar cables and with a main span of slightly over 950 feet. The masonry towers, or gatehouses, over the anchorages, are of beautiful design and form a most pleasing entrance.

The great arch bridge over the Rhine at Bonn, Germany, has entrances or portals of very appropriate design, and portals of very elegant design and monumental in character at each end of the main span.

FIGURE 10. LUXEMBOURG'S GREAT STONE ARCH BRIDGE.

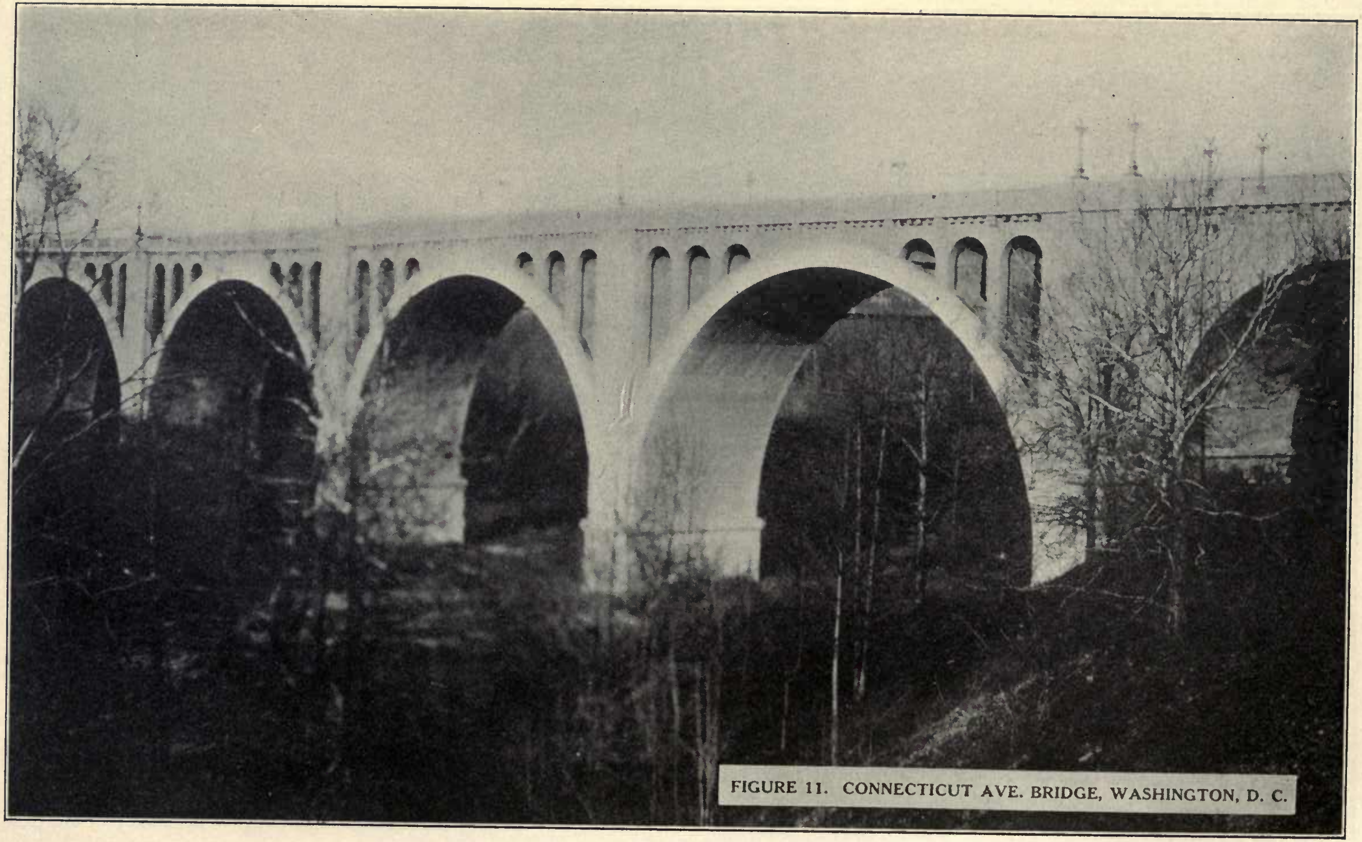

FIGURE 11. CONNECTICUT AVE. BRIDGE, WASHINGTON, D. C.

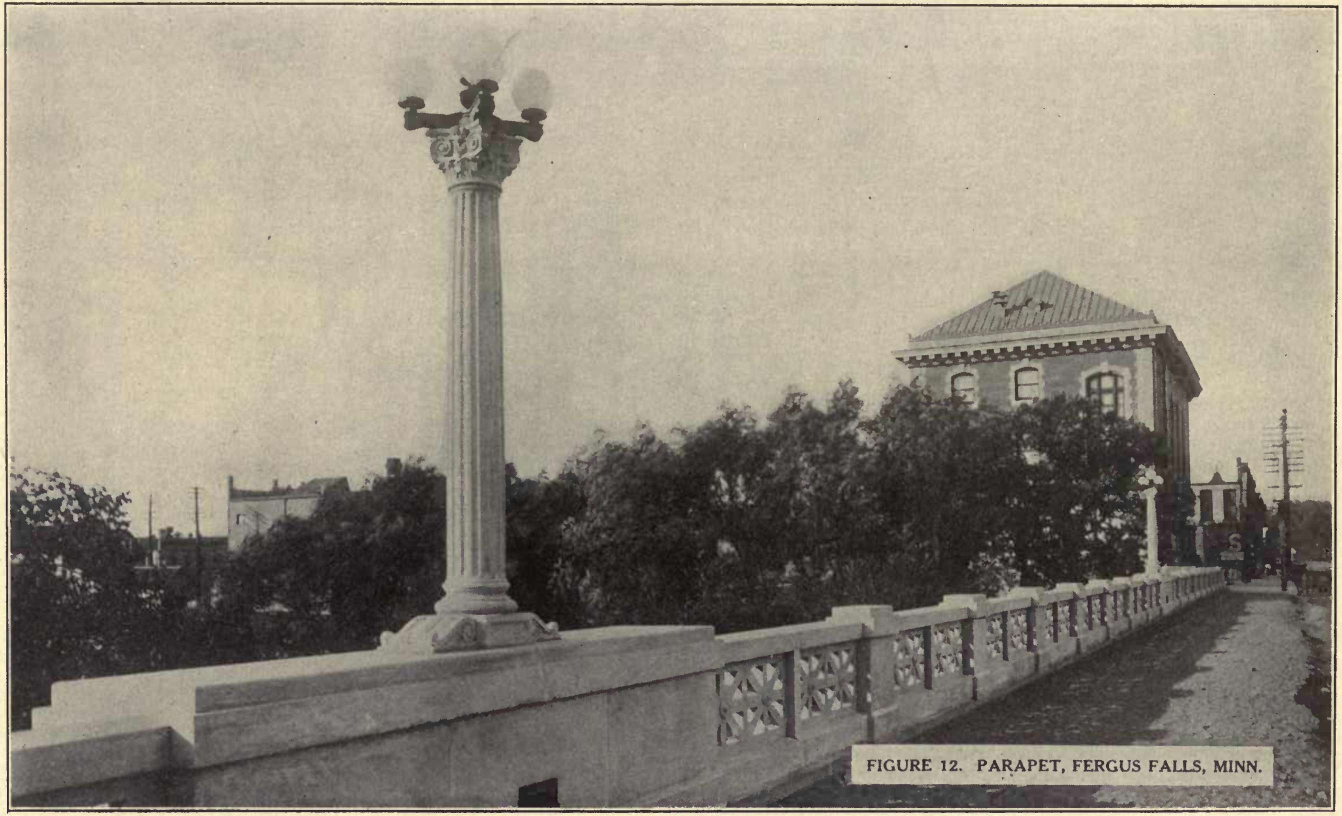

FIGURE 12. PARAPET, FERGUS FALLS, MINN.

The Memorial arch in Bushnell Park at Hartford, Conn., of similar design, forms the portal at one end of the stone arch bridge, and is one of the handsomest works of this class in the United States.

Many suspension bridges have towers of elegant design, and the Cincinnati bridge, built by the elder Roebling, has towers very well designed and among the most satisfactory in this country. It is a curious fact, however, that both this and the great East River bridge, designed by the same engineer, are lacking in appropriate capping or finishing of the towers; the attic story included in the original design of the East River bridge towers having never been built, and the unsatisfactory minarets covering the saddles of the Cincinnati bridge not being in harmony with the remainder of the towers. When the bridge was reconstructed, some years ago, these were removed and hemispherical caps used to replace them, but the appearance was only slightly improved.

The foregoing examples are given to call forcible attention to the care that should be exercised in the design of the architectural features of bridges. Unless the engineer is entirely sure of his ground, an architect should be employed to assist in the design, or at least supervise the design, of the architectural portions of bridges of any prominence or importance. Even the parapets, balustrades, and railings should be designed with great care, and the balustrade and lamp posts of the Fergus Falls, Minn., bridge (Fig. 12) show how pleasing such parts of a bridge may be made. The simple concrete parapet used by the author on the abutments of the Knoxville Cantilever were carefully designed with classic proportions and added greatly to the appearance of the entire structure.

The entrances to the Connecticut Avenue bridge in Washington, D. C., already referred to, are flanked by lamp posts of beautiful design and huge concrete lions, which add to the monumental character of this great structure.

The practical design of bridges will not be taken up in detail in this paper, but it is fitting to call attention to the care which should be used in the engineering features. The foundations, being a most important feature, should be carefully located to insure permanence, the least possible interference with the waterway and navigation, and of as reasonable a cost as is consistent with the other features of the structure.

Where the bottom is hard and at no very great depth, cofferdams can be used to construct the footings and base of the piers up to water level.

Where the bottom is soft or of material liable to scour, piling must be used, or open dredged caissons or pneumatic caissons employed.

Each particular foundation must be designed with reference to the structure and load it is to carry; piers and abutments for arch spans requiring to be practically unyielding.

Many of the bridges already referred to are illustrations of the possibilities of making of bridge piers architectural features of the

structure, and the piers of the Blackwell's Island or Queen's Bridge in New York City are examples of the artistic character of the piers of many of the modern bridges in this country.

The foregoing discussion has referred principally to the architectural features of bridge construction; it being assumed that a competent bridge engineer would be employed for any structure, to carefully calculate the stresses and proportion the parts. Therefore only the general engineering questions will be discussed.

The types of bridge to be employed for different locations may be classified as follows:

Spans under five feet in length, steel beams, stone beams, concrete steel beams, or masonry culverts.

Spans from five to twenty-five feet, steel beams, concrete steel beams, or masonry arches.

Spans from twenty-five to one hundred feet, steel girders, steel trusses, steel arches, or masonry arches.

Spans from one hundred to three hundred feet, steel trusses, steel arches, steel suspension bridges, or masonry arches.

Spans from three hundred to five hundred feet, steel trusses, arches, cantilevers, or suspension bridges.

Spans from five hundred to one thousand feet, steel arches, cantilevers, or suspension bridges.

Spans one thousand feet and upwards, steel cantilevers or suspension bridges.

The floors of bridges, which are the part of the structures continuing the roadways over streams, are in their simplest forms simply wooden joist and plank flooring. The joist must be calculated for the uniform load and also for concentrated loads to be carried, and they are usually spaced two feet center to center, and should never be spaced wider apart in feet than the thickness of the plank in inches.

The roadway plank should never be less than three inches in thickness, and as much thicker as is demanded to withstand the wear from the traffic to be carried, or a wearing surface may be placed over the first layer of plank.

The use of steel joists with this type of floor (Fig. 13) forms the simplest kind of a bridge floor which may be said to be of a permanent form.

Where the plank has been creosoted, or treated with preservative, and a pavement of wood blocks used, the floor should prove to be the best form that can be employed, where it is necessary to have a light and also a durable roadway.

Steel joists or girders carrying buckle plate (Fig. 14) and a concrete base, or concrete steel base without the buckle plate, may be paved with treated wood blocks, brick, concrete wearing surface, asphalt block, or sheet asphalt.

Stone and arch bridges may have a roadway on the supporting arches of any of the permanent forms that have been mentioned.

Floor systems must be calculated to carry their own weight, a uniform load, which is usually 100 pounds per square foot, and

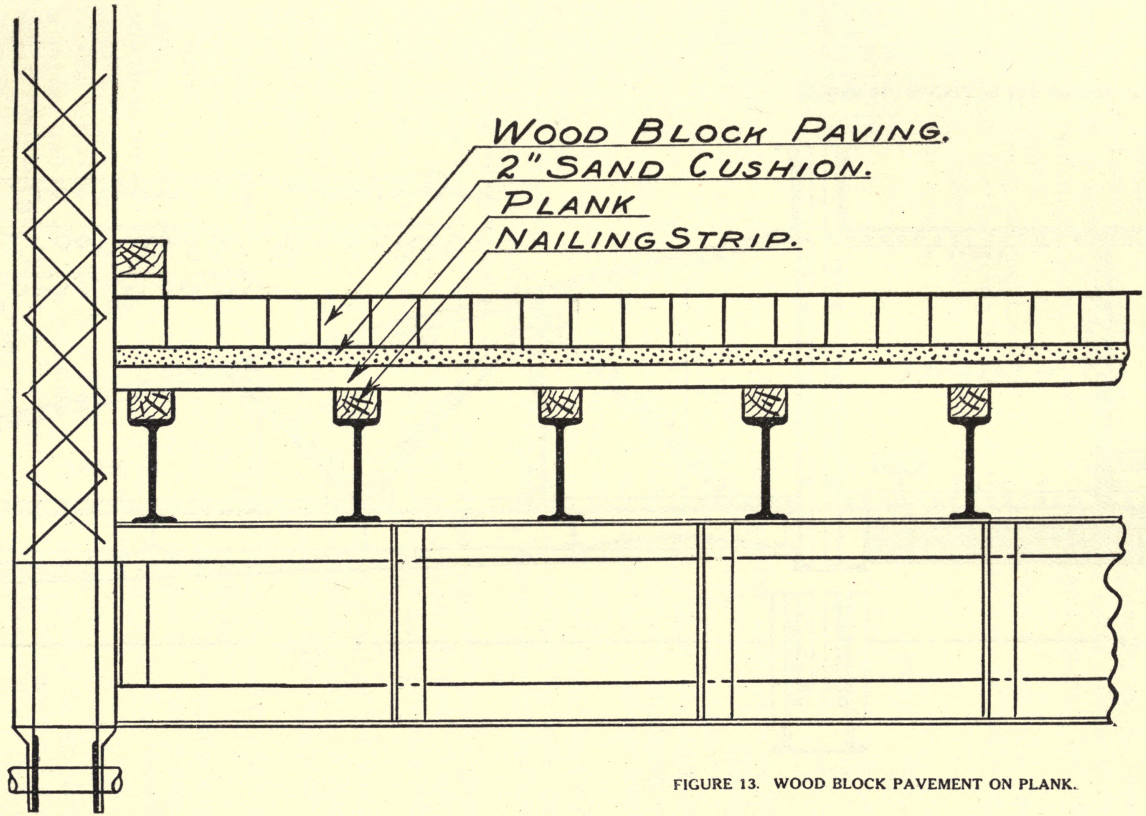

FIGURE 13. WOOD BLOCK PAVEMENT ON PLANK.

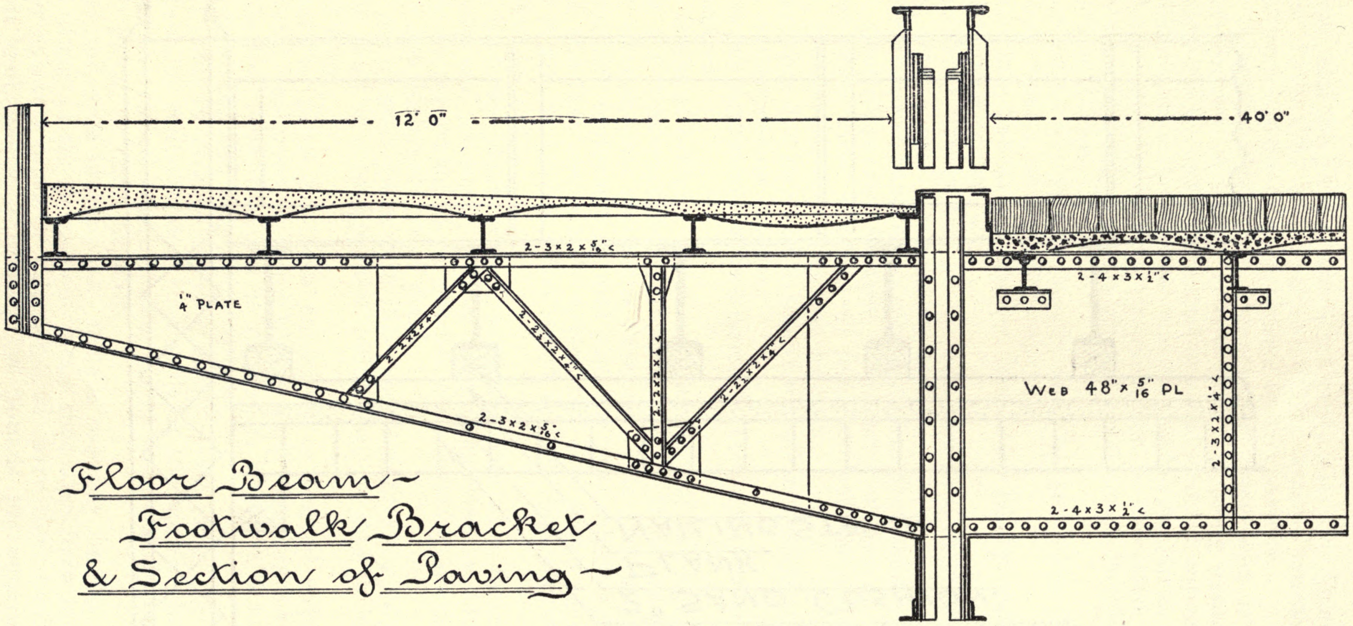

FIGURE 14. BUCKLE PLATE BRIDGE FLOOR.

such a concentrated loading as they may be called upon to support, such as a traction engine, steam road roller, or electric cars.

The structures or trusses must be proportioned to carry their own weight, a wind load, a snow load in some cases, temperature stresses, centrifugal force, when on a curve, and longitudinal or traction stresses.

The live load per square foot to be carried by trusses may be taken from the following table; class A being city or suburban bridges, and class B being country bridges:

Class	A	B
Up to 100 feet	100 lbs.	90 lbs.
100 to 150 feet	100 "	80 "
150 to 200 feet	90 "	70 "
200 to 300 feet	80 "	60 "
300 to 500 feet	70 "	50 "

Should either one of the two first-class general specifications for highway bridges be used in designing a bridge (Cooper's or Thacher's), the loads provided for therein are proper ones to employ.

The class of steel to be used in constructing short and medium length spans should be soft-medium, with an ultimate strength of from 55,000 to 65,000 pounds per square inch, and nothing more than fair reaming need be done in the shop.

For medium length and long spans, medium steel should be used, having an ultimate strength of from 60,000 to 68,000 pounds per square inch; but for important bridges this should be punched and reamed, or have the holes drilled.

For long spans, at least for compression members under great stress, high steel may be used and all rivet holes drilled. Nickel steel is also beginning to be used for long spans and members subjected to great stress.

Stone bridges of short span may be built of some of the softer kinds of stone, such as sandstone or the more durable kinds of limestone, although harder kinds, such as marble or granite, are preferable.

Stone bridges of medium or long span should be constructed of hard stone, such as iron limestone, marble, or granite.

Reinforced concrete bridges should be constructed with the most careful workmanship and of the very best materials. The cement, whether imported or of local manufacture, must pass the requirements of the American Society for Testing Materials.

The inspection of the materials entering into the construction of a bridge and of the construction work as well should be carefully and conscientiously done, and always be placed in the hands of men who will not "strain at gnats and swallow camels." The inspector must bear in mind that he is the one to see that both his employer and the contractor get justice.

When the conditions met with vary from those contemplated by the plans and specifications, in justice to both the employer and the contractor, the inspector should request the engineer to make such

changes as are just and equitable to the contractor, and at the same time see that no injury be worked upon the owner.

No more fitting words can be used in closing this paper than to quote the foreword from Cooper's Specifications:

"The most perfect system of rules to insure success must be interpreted upon the broad grounds of professional intelligence and common sense."

PORTLAND CEMENT, ITS MANUFACTURE AND USE.

In the absence of **Spencer B. Newberry,** of Ohio, his paper on "Portland Cement, Its Manufacture and Use," was read by **City Engineer R. H. Thomson,** of Seattle, who prefaced the reading by saying that the paper was by Professor Newberry, and it must not be taken for granted that all the statements contained therein relating to the use of cement for a road surface were concurred in by the reader.

Paper by S. B. Newberry.

Gentlemen:

The beginning of the twentieth century is often spoken of as the opening of the "Cement Age," owing to the belief, held by many thoughtful obeservers, that cement is destined to be our most important and widespread building material. Certainly the phenomenal growth of Portland cement manufacture in this country, from one-half million barrels in 1890 to fifty million barrels in 1908, and the evidences we see all about us of the adoption of cement concrete, in place of stone, brick, and wood, for abutments, foundations, bridges, and complete buildings, show that cement is making rapid strides toward a position of leading importance among materials of construction.

The reasons for this successful progress are evident. Cement is the "essence of rock" in portable form. A relatively small proportion of it suffices to bind together any available fragmentary materials, sand, gravel, slag, stone refuse, into solid masses of any desired shape, and of strength and hardness comparable with that of monolithic blocks of quarried limestone. Where good gravel is obtainable at low cost, walls can be laid up in cement concrete at lower cost than of lumber or common red brick. With steel reinforcement it gives a combination which shows to best advantage the good qualities of both materials. Within the past few years, great progress has been made in the beauty and architectural character of concrete structures, and there are now many edifices of concrete which rival in beauty the best examples of construction in sandstone and marble.

This is especially the case on the Pacific Coast, and there is no doubt that Western architects have taught the world a lesson on the artistic possibilities of concrete. The excellent showing which

cement has made in recent great fires and earthquakes has also greatly increased its use for building. The city of Port of Spain, Trinidad, destroyed two years ago, is being rapidly rebuilt, almost exclusively of concrete structures, and nearly as marked a tendency toward concrete is to be seen in the new San Francisco.

Striking as these growing architectural uses may appear, much greater amounts of cement are consumed in work in which beauty is of secondary consequence, as in wharves, sea walls, breakwaters, locks and dams, and in tunnels, abutments, and foundations of bridges. A multitude of smaller uses, on farms and in dwellings and factories, aid still further in absorbing the output of the ninety operating cement works of the country.

In view of the magnitude which the industry has so rapidly attained, it may be that a brief explanation of the process of manufacture of cement, and the manner in which it is tested and used, will be of interest to the members of the Good Roads Association.

Hydraulic cements are materials in the form of dry powder, which, when mixed with water, solidify and harden to a stonelike mass.

You all know that ordinary lime hardens only by drying out, and remains soft if kept under water. The Romans found, however, that certain kinds of volcanic scoria, called "pozzuolana," had the property of making lime hydraulic. Mixtures of lime and pozzuolana were therefore used by the Romans in important engineering works, many of which are in good preservation to-day; for example, the dome of the Pantheon at Rome, a monolithic mass of concrete over a hundred feet in diameter.

In recent years it has been found that blast furnace slag acts like a pozzuolana, and slag cements have been made on a considerable scale by simply grinding granulated slag with slaked lime.

When Smeaton built the Eddystone lighthouse, off the coast of England, in 1756, he made his mortar by mixing lime and Italian pozzuolana, and in preparation for this work he made a series of experiments to determine why certain kinds of lime gave better results in water than others. He found that limestone which on dissolving in acid left a considerable insoluble residue gave lime of the best water-hardening quality, and identified this insoluble residue as *clay,* thus showing that the combination of clay and lime, by burning, is the source of hydraulic properties. He wrote in his journal: "I did not doubt but to make a cement that would equal the best merchantable Portland stone in solidity and durability." This remark of Smeaton is often quoted as the probable source of the term "Portland cement."

Soon after the publication of these experiments, at the end of the eighteenth century, the manufacture of "Roman cement" was begun in England, by burning calcareous clay nodules found on the coast of Kent. These nodules contain carbonate of lime mixed with so large a proportion of clay that after calcination they do not slake with water, but on grinding to powder they form a quick-setting natural cement. The calcination must be carried on at low heat, as at higher temperature the large amount of clay present causes

the clinker to melt to a slag, which has no cementing properties. Similar natural cement was made in France at about the same time, and has been manufactured on a great scale at or near Louisville, Rosendale, Milwaukee, and at other points in this country. Owing to the abundance, cheapness, and superiority of Portland cement, however, the manufacture of natural cements has greatly declined in the past few years, and is now comparatively insignificant.

In the earlier years of the last century the importance of exact proportions of lime and clay, to produce cement of highest quality, gradually became realized, and in 1827 Aspdin began the manufacture in England of "Portland cement" from an artificial mixture of lime or limestone and clay. Other makers gradually improved the quality of the product, and the industry became an important and rapidly increasing one, in England and Germany, from about 1850. It was found that mixtures containing certain proportions, usually about 25 parts clay and 75 parts carbonate of lime, could be burned at high white heat without melting, and on grinding the resulting clinker, a sound, slow-setting, and extremely strong cement was obtained. Mixtures higher in lime yielded cement which swelled and cracked with water, while mixtures higher in clay fused and lost their hydraulic properties at high temperature, though by burning at lower heat inferior, quick-setting cement, similar to natural cement, was produced. It required many years to perfect the chemical control of the mixture and to develop the manufacturing processes of raw grinding to necessary great fineness, burning, and grinding of the finished product, to the point of production of cement of uniform and high quality. Improvement in economy of manufacture and quality of product is, in fact, still going on, though at the leading works in this country and Europe the process has been brought to so systematic a basis that further improvements must necessarily be slow and gradual.

The successful manufacture of Portland cement began in this country at Coplay, Pa., in 1878, but no important production took place until after 1890. Up to that time all Portland cement was burned in vertical kilns, similar to lime kilns. This process required the raw mixture to be molded into bricks and dried before burning, and the economical in fuel was expensive in labor.

With the high rate of wages in this country, therefore, American manufacturers could hardly compete with those of Europe. A remedy was found in the rotary kiln for cement burning, which had been tried in England in 1885, but abandoned. This consists of a revolving steel cylinder, slightly inclined and lined with fire brick, heated by a flame entering at the lower end, into which the powdered cement mixture is continually fed at the upper end, and in its passage through the kiln is brought to a white heat and continuously discharged at the lower end as well-burned clinker. The rotary kiln was soon brought to complete success in this country, and with crude petroleum as fuel proved so great a labor-saving device that cement could be made with profit. From that time on the industry increased with great speed. Coal dust was soon substituted for crude oil as fuel, and the size of kilns was steadily in-

creased, from 5 or 6 by 60 feet, to the present usual size of 8 by 100 or 120 feet. At two Eastern works, in fact, kilns 12 by 230 feet are now being built.

We may, then, classify hydraulic cements as follows:

1. Pozzuolana or slag cement, made by grinding volcanic scoria or slag with dry slaked lime.

2. Natural cement, made by calcining natural limestone containing a high proportion of clay at low heat, and grinding the calcined stone to powder.

3. Portland cement, made from an artificial mixture of limestone or marl with clay or shale, in exactly correct proportions, burning the mixture at a white heat, and grinding the resulting clinker to powder.

The materials from which Portland cement is made are:

1. Carbonate of lime, in the form of limestone, chalk, or marl;

2. Clay or shale.

These materials are found in abundance in nearly all parts of the United States. The only important requirements as to composition are that the stone shall be nearly free from magnesia and the clay or shale relatively high in silica. In some localities, notably in the Lehigh valley, in Pennsylvania, clay-bearing limestones of nearly correct composition for cement are found, and it is there necessary only to select the strata and grind them together in the right proportion. If stone of exactly correct composition could be found, this could be made into cement clinker by simply quarrying and burning. When it is understood, however, that a variation of 1 per cent. in carbonate of lime from the correct standard is sufficient to spoil the resulting cement, it will be realized that deposits of such exact and uniform composition are not to be expected in nature, and that it is in all cases necessary to prepare artificial mixtures to obtain the result desired. In most parts of the country, limestone, more or less pure, and clay or shale, are the materials employed.

The process of manufacture of Portland cement, as carried on at the best modern plants, will now be briefly described.

The stone is quarried, crushed, and dried. The clay or shale is dried and broken up, and the two materials, under the supervision of the chemist, mixed in exactly correct proportions. The mixture is then ground to impalpable powder, usually in two or three operations, in ball mills and tube mills, and this is the part of the process requiring the greatest amount of machinery and power, and on its thoroughness the quality of the product largely depends. Sound cement cannot, generally, be made by burning mixtures coarser than 98 per cent. passing a sieve of 100 meshes to the linear inch. A plant making 2,000 barrels of cement per day uses about 600 tons, daily, of raw material, and it will be appreciated that to grind this amount of hard limestone and shale to the fineness of flour is a serious undertaking.

The prepared raw material is now fed into the revolving kilns. These are heated internally to a white heat by jets of coal dust and air, blown in at the lower end. The raw material as it passes

through the kiln is gradually heated to redness and balls up into little rounded masses. These become white hot at the zone of highest temperature, and are finally discharged as clinker, which on cooling appears like fine black gravel of the size of corn. This clinker now goes to the grinding mill, where another series of ball and tube mills reduce it to a gray powder, of such fineness that 92 to 94 per cent. passes a 100-mesh sieve. This is the finished Portland cement.

This appears to be a simple process, and yet the excellence of the product depends upon the close observance of certain rules and precautions. Good Portland cement should be slow-setting; that is, when mixed with water to a stiff paste, made into a thin-edged pat or cake on a piece of glass, and kept under a damp cloth, it should not *set,* so as not to be marked with the finger-nail, in less than two or three hours. After setting it should increase rapidly in hardness, and within twenty-four hours should be with difficulty scratched with the point of a knife. Such a pat, kept in water for a month, or exposed for five hours to steam over boiling water, should still remain hard, and show no sign of expansion cracks around the edges. If the pat sets within a few minutes, or if it softens in steam or water and shows expansion cracks, the cement is defective, and may make serious trouble in use.

Now, let me tell you, in a few words, what are the chief errors in the process of manufacture which may produce the defective quality above described.

These are:

1. Incorrect proportions of lime and clay. The more lime a cement contains, *up to a certain point,* provided the raw grinding and burning are properly done, the better and stronger it will be. This point may be determined exactly, from analysis of the materials, by certain well-known formulas, and the problem which the cement chemist has to solve is to keep his mixture as close to this lime limit as possible, without ever exceeding it. Even one-half per cent. of lime more than this limit allows will make the cement unsound; that is, it will swell and crack after setting. Such cement would be highly dangerous to use, especially as its expansion may take place some days or even weeks after it has been put in place in a bridge, foundation, or building, perhaps causing collapse of the structure. Fortunately the cold pat test in water for 28 days, or the boiling test in steam for 5 hours, is a certain means of detecting this defect, and cement which passes either of these tests may safely be considered sound, and used without fear in the most critical work. On the other hand, if the lime in the mixture is too low, perhaps two per cent. below the lime limit, the cement is liable to prove quick-setting and low in strength. Cement chemists generally, therefore, hold their mixtures at one-half or one per cent. below the limit, and at well-conducted factories the variation in lime will hardly exceed one-fourth per cent. either way from the standard chosen as correct.

Lest there may be some well-posted cement man here who will think I am speaking too positively on this point, I will qualify the

above statements by saying that different materials vary considerably in amount of allowable variation. Clays high in silica and low in alumina and iron, for example, permit much wider variation in proportion of lime than clays of more aluminous composition.

To explain this fully would take us further into the domain of cement chemistry than you would have patience to go to-day.

2. Coarse grinding of raw material. In the burning of cement mixtures, the materials are not fused, but merely brought at a white heat to a sintered or softened condition. In revolving kilns, also, the passage through the zone of high heat takes place in 15 minutes or less. It is plain, therefore, that the materials must be very finely divided, in order that each particle of lime may find within easy reach the particle of clay it needs, and that the combination of the two materials may be uniform and complete. If coarsely ground, the fine particles of lime will combine with all the clay, producing an over-clayed compound, while the coarse particles of lime remain free, and give rise to dangerous expansion. A coarsely ground mix will therefore yield cement having, at the same time, the faults of that made from an over-clayed and an over-limed mixture; that is, it may be quick-setting, weak, and unsound. It may safely be said that imperfect grinding of raw material is the source of more faulty cement than all other causes combined.

3. Imperfect burning. Well-burned clinker is black, hard, and glistening; underburned clinker is brownish and comparatively soft. Underburning may make cement quick-setting and unsound. It should be said, however, that this fault is of rare occurrence, and that correctly proportioned and well-ground raw material may be light-burned without injury to quality.

4. Imperfect final grinding. Coarsely ground cement may be slow in hardening and show low strength, especially when mixed with sand. Fine grinding increases the sand-carrying capacity of cement, and improves its strength, especially at short periods. There is such a thing, however, as grinding cement *too fine,* and thus making it quick-setting, and causing it to gain strength too rapidly.

Engineers generally require a gradual increase of strength, and look suspiciously on cement which does not show a good gain between seven and twenty-eight days. This requirement is difficult to meet with extreme fineness of grinding, as a very finely ground cement may gain practically its whole strength within seven days or less. The usual requirement of 92 per cent. passing a 100-mesh sieve is a reasonable one, and the best brands generally exceed this figure by one or two per cent.

To resume, badness of cement is generally caused by imperfect mixing and grinding of the raw material before burning, less often by incorrect proportions of raw materials, and rarely by imperfect burning or final grinding.

The testing of cement can, of course, be completely carried out only in well-equipped laboratories. A few years ago there was little uniformity and much confusion in methods of testing; but the labors of the Committee on Uniform Tests of Cement, of the

American Society of Civil Engineers, have resulted in the establishment of well-defined rules and methods which are now closely followed by engineers throughout the country. The report of this committee, and also the Standard Specifications for cement, established by the American Society for Testing Materials, have been published in pamphlet form by the Association of Portland Cement Manufacturers (Land Title Bldg., Philadelphia), and will be gladly mailed on request.

The ordinary tests are the determinations of fineness, time of setting, soundness or constancy of volume, and strength. The first three tests have been briefly described in the foregoing. Strength is determined by making briquettes of neat cement, or cement and sand, one to three, one square inch in smallest section, and, after hardening one day in moist air and the remaining time in water, these are pulled apart at 7 days, 28 days, and longer periods, by means of a simple testing machine. Good cement will generally show, tested neat, 300 pounds, in one day, 600 pounds in 7 days, and 700 to 800 pounds in 28 days; and with three parts standard sand at least 200 pounds in 7 days and 300 pounds in 28 days. Compression tests, by pressing cubes of cement or concrete in massive crushing machines, are also made in well-equipped laboratories, but are not generally necessary to determine acceptance or rejection, as it is well known that good Portland cement will generally show a resistance to compression about ten times greater than its tensile strength.

A few words, in closing, on the rational use of cement. Pure or neat cement is almost never used, and to give useful results admixture with sand and gravel or broken stone is necessary. Sand alone is a very poor material to mix with cement. With three parts sand a strength of perhaps 200 pounds may be expected, while with three parts good gravel, ranging from coarse pebbles down to sand, the strength will often reach 600 pounds. Materials should be so chosen that the voids will be filled as completely as possible, to yield a mass of greatest possible density. Ordinarily, concrete is made of one part cement, two to three parts sand, and four to six parts coarse gravel or broken stone. The amount of water used should be such as to give a soft, plastic mixture, which will *quake* when rammed, like a jelly. Mixtures made too dry will always be soft, earthy, and rotten, and no subsequent wetting of the concrete will materially help matters. This fault is often seen in hollow concrete building blocks. To give good results these must be made as wet as possible, up to the point at which the mixture begins to stick to the plates or to sag out of shape on removing from the molds.

Thorough mixing is essential, to develop the full strength of concrete. This is difficult to accomplish by hand labor and almost certain to be slighted, except when under the eye of the foreman. There are many excellent concrete mixers on the market, which save greatly in labor and give strengths practically equal to those which can be obtained on a small scale in the laboratory.

It should always be kept in mind that cement hardens by combining with water and crystallizing. As soon as the work dries out, therefore, the hardening ceases. Concrete must be kept *moist* until thoroughly hardened. Too rapid drying out of the surface is also the most frequent cause of shrinkage cracks.

The question of the use of concrete for street and road pavements has been widely discussed, and there are already many examples of successful concrete pavements in various parts of the country. This subject was fully discussed in papers read before the Association of Cement Manufacturers at Philadelphia two years ago by Mr. H. L. Weber, Chief Engineer of Ft. Wayne Traction Company, Ft. Wayne, Ind., and Mr. Walter Hassam, Manager Hassam Paving Company, Worcester, Mass. Bulletin No. 14, published by the Association, containing these papers and discussion, is now out of print, but it is hoped that a new edition will soon be published. The Association's Committee on "New Uses" lately offered prizes for best papers on concrete roadways, through the agency and by the help of the Good Roads Magazine, and the two papers selected for prizes will soon be published in that Journal. The May number of the Concrete Review, published by the Association of Cement Manufacturers, which has been delayed in publication, will be chiefly devoted to concrete roadways.

The sum of all the evidence on this question seems to be that concrete pavements, if properly made and of suitable material, are low in cost and of excellent wearing qualities. There is in cement a quality of toughness and resistance to wear which is superior to stone or brick. This is shown in the great superiority of cement sidewalks over flagstone, in point of durability. I have seen cement patches on flagstone walks, around which the stone has worn away to the depth of an inch, while the trowel marks on the cement surface are still visible. A well-laid macadam road is fairly durable. Does it not stand to reason that if the broken stone and sand or gravel, of which the surface is composed, were held together by a small amount of cement, the life of the road would be greatly increased? Here, however, comes the question of the wearing quality of the broken stone itself. Limestone is soon ground up under heavy traffic, and blows away in dust. To show resistance to wear equal to that of the cement binding material, the aggregate should be a hard, tough substance, such as quartz gravel or crushed trap rock. Where such materials are to be had at reasonable cost, there is no doubt that cement pavements can be laid, at a cost of 75 cents to $1 per square yard, which will last longer and require less repairs than paving brick or stone. If Portland cement can play an important part in the development of *good roads* in our country, it will certainly be a ground for pride on the part of all those who are connected with its manufacture.

The reading of this paper was followed by considerable discussion.

Mr. Samuel Hill: I would ask Mr. Powers if he knows any place where pavement of that character is to be seen.

Mr. Powers: The Speedway on Long Island.

Mr. Lancaster: This was made of concrete reinforced. I think the construction of that road was entirely for automobile purposes, and not with the idea that it would be used for any other kind of traffic. For that purpose it is doubtless well suited, but for general traffic I, personally, do not believe it would wear well.

Mr. R. H. Thomson: So far as this concrete Speedway on Long Island is concerned, it was definitely stated that it was not expected it would withstand the impact of horses' feet, but was to give the particular surface which would hold the automobile. The road is exceptionally well suited for a speedway for automobiles, but I would not expect it to stand the impact of the horses' feet. There are a few streets in Chicago of granitoid pavement which are said to wear well. I have been unfortunate not to have seen a good section. Possibly there is some one present who has.

Mr. Fowler: You all seem to be opposed to a concrete pavement, and in the absence of defenders I want to say, in connection with a road built about twelve years ago, that the Knoxville Bridge roadway, 40 feet in width, was finished with a cement wearing surface and lasted very well indeed for city traffic of all kinds, and it was only a year or so ago that it was necessary to let a contract for resurfacing, so I know of a third of a mile of concrete pavement which has stood very well for about twelve years.

Mr. Eldredge: In Washington we have a pavement about a mile in length, which was built of concrete. The pavement was built about three years ago, I believe, and I saw it very recently, and it does not show up very well. The particular trouble seems to be with the expansion joints. Wherever they were placed the pavement has gone to pieces, and there are places where there are holes in the pavement as wide as two or three feet at the expansion joints. That is an exceedingly heavy traffic road, possibly a thousand wagons every day, the heaviest in the District of Columbia, and for that reason the War Department hoped to build a successful road that would stand, but so far it has not proved entirely satisfactory.

Mr. Samuel Hill: I have a piece in mind, the only piece I have found in this country of that character, and I have found it very unsatisfactory. The wear at the different sides of that street is not uniform.

Mr. Morrison: There is mention made in the paper of the Hassam pavement. If I understand it, there have been several experiments made in this city by the Hassam people, and perhaps it would be well for Mr. Thomson to give us an account of this.

Mr. Thomson: We have two or three experimental sections of the Hassam pavement in the city. Probably there is 1,200 feet constructed in the residential district. This has been in service about eighteen months, and only about two wagons pass daily over the pavement, and it is in perfect condition, and at this rate of travel I think will last a lifetime. On Westlake avenue there is about 100 feet of Hassam pavement. Part is in excellent condition; but it has required to have very considerable repair. It has been in about two years. As to the relative cost, there is very little difference between the cost of that and our asphalt pavement in the city; probably it is 80 per cent. of the cost of asphalt. We are under this difficulty: That we have not any great supply of good stone for macadam of any kind close at hand, and the cost of delivery is a very considerable expense, and it is much more here than many other cities. We have to bring our stone from quite a distance.

Mr. Lancaster: I would like to qualify what I said about not being favorable to concrete pavement, by saying that I do not believe it can be economically repaired. I think that is one of the troubles Mr. Thomson has spoken of; that while it has been used quite extensively in some of the Eastern cities, the fact that these expansion joints cannot be repaired easily is against it. Another feature is that, in driving horses over it, it is absolutely unyielding, and is injurious to a horse. There is no yielding of any kind whatever, and it is rather hard on the horses that are driven over it. This Blome pavement is a new one, and is being used to some extent in the vicinity of Chicago, and I understand some of it is being put in in Walla Walla, in this state.

Mr. Powers: With a view to getting some form of concrete pavement, some manufacturers offered prizes for the best paper on that form of roadway, and they asked us to publish the papers.

The Long Island Parkway is one of the most noted of these roads, and that I understand has been averagely successful. Understand, I am not defending the concrete more than any other; but I have understood that it has been successful from the automobilist's standpoint. I have not been able to get the road builder's opinion of it. Mr. Ross, the city engineer of Worcester, Mass., has, I understand built a road of concrete and found it serviceable, and he did tell me personally he was quite well pleased with it so far.

Mr. Samuel Hill: What Mr. Powers says is true with regard to the Long Island pavement. Mr. Lancaster and I had the pleasure of seeing it with Mr. Vanderbilt, who built it, and we drove over it in an automobile. It is not suited for use on public highways.

Mr. Fuller: I wrote to the city engineers of a number of the New England states, and received replies from them to the effect that the Hassam pavement was being laid to rather a great extent, that it was satisfactory as far as they had been able to tell within their experience of two or three years, that it was easily repaired, and the general impression I got was that the Hassam pavement was going to be laid to a much greater extent than it had been. I have been unable to learn anything definite as to what has been done during the last two years. If there is any one here that can enlighten us, I would be pleased.

Mr. Samuel Hill: We will call on Mr. Thomson.

Mr. R. H. Thomson: I do not think there has been any advance or improvement in the production of Hassam pavement. The owner of the patents himself does not claim any great advance has been made. He claimed he was experimenting with a new type of binder, which, instead of being rigid, as Portland cement, and destroyed whenever broken, was slightly plastic and would rebound under traffic, and he hoped soon to bring that type of pavement under notice. I have seen no notice of it. Perhaps he has introduced it somewhere, I do not know.

Mr. Landes: I am disappointed in what has been said in regard to the Hassam pavement, for I am interested in local conditions, and have been interested in the experiments of the Hassam pavement here, and I think Mr. Thomson will bear me out in saying that the man who undertook to lay the Hassam pavement here was not practical in his doing, and undertook to lay it on ground where the

asphalt would not lie on account of being soft, and he did not have the right tools, and was obliged to use the wrong rollers, etc., and could not mix it as it should be.

Mr. R. H. Thomson: From my observation, the difficulty with the Hassam pavement on Westlake Avenue, does not result from the causes mentioned by Prof. Landes, but results principally from the inferior quality of the stone used. The stone, upon examination, has been found to be very much softer than the mortar in which it is embedded and very soluble. In addition to that, the stone is very unequal in its texture. As a result, when any one of these stones is crushed from any reason, there has been left a small hole in the pavement, and the impact of the horses' feet passing over in a short time produces a pocket of considerable size. The inferiority of the stone has unquestionably had more to do with the failure of this pavement than any other cause, so far as I am able to determine, and for that reason we cannot regard the results obtained by the experiment on Westlake Avenue as being fair to the Hassam people. My objections to concrete pavements in general are these: First, such pavement is very hard on horses, because of its unyielding surface. Second, where the stone and the mortar are of equal hardness, they wear very smooth and afford but moderate foothold. Third, when any crack or crevice is made by any means whatever, it affords an initial point for ravelling and pocketing. Fourth, it is very difficult to patch these pocketed places so as to obtain a uniform bond and maintain a uniform surface.

Mr. Samuel Hill announced that there would be a most interesting session on Tuesday, and the further proceedings were adjourned until the following day at 9:30 a. m.

TUESDAY, July 6th, at 9:30 a.m.

CHARACTERISTICS OF STONE SUITED FOR USE AS MACADAM OR FOR PAVING BLOCKS.

The first paper read at the morning session was by **Professor Henry Landes,** of the University of Washington, on the above subject, and was as follows:

Paper by Prof. Henry Landes.

In the making of the best roads of a permanent character, a large number of factors must enter. Such roads are the results of many years of experience, and necessarily involve engineering skill of a high order. Without enumerating all of the elements of success, it is safe to say that our best roads can be had only by the fulfillment of at least these requirements:

1. Selection of a proper gradient.
2. Good drainage of the roadbeds.
3. Use of first-class stone in construction.
4. Highest engineering skill at every stage.
5. Continued maintenance and persistent care.

Of the above essentials my topic has to deal only with the stone which may be used, and in the selection of such material, suitable for macadam or paving, the chief considerations are these:

1. The quality of the rock, or its inherent ability to withstand every test which any kind of traffic upon the road might demand.
2. The accessibility of the stone, which determines the cost at which it may be delivered to the points where needed.
3. Demands of the particular road, taking into account such things as the nature of the traffic and the characteristics of the climate.

The principal qualities desired in stone may be summarized as follows:

1. Hardness, or the resistance offered to any abrading action. This quality is determined largely by the hardness of the individual minerals composing the stone.
2. Toughness, or the coherency among the individual particles of the stone, which holds the mass together, when struck by a hammer, a hoof, or a wheel.
3. Cementing power, or the natural binding qualities possessed by the crushed rock, whereby it holds together firmly when moistened and rolled. This quality is particularly desired in stone for macadam purposes, although it is helpful in paving blocks as well. It is probable that in the future the relative value of this quality will decline with the increasing use of cementing substances of an artificial character.

In determining the presence or absence of the above qualities in a stone, the following three classes of tests may be employed:

1. Practical use of the stone in a road for a term of years. Since the best tests are always made in the laboratory of experience, long-continued successful use of a stone affords the only test which may be regarded as final. The older a community may be, the more this test may be relied upon; but manifestly the practical use of the stone cannot be utilized in the building of roads in a state as young as Washington.

2. Observations on the stone at its natural outcrops, with regard to its resistance to weathering and erosion, behavior under frost action, binding qualities of the resultant subsoil, etc. This test is one very commonly depended upon, and when applied with intelligence will yield valuable results.

3. Laboratory tests and experiments, approaching actual conditions as far as possible. The difficulties here are those attendant upon such vast differences in the scale of operations, and upon the impossibility of attaining in the laboratory conditions similar to those of a highway. The results of these tests can only be regarded as approximate, and never as wholly conclusive.

In all tests or observations made upon a stone to determine its qualities necessary for road purposes the following analysis seems desirable:

1. The minerals present; kinds and relative amounts of each, with such physical characteristics as hardness, cleavage, and specific gravity. When one considers that a rock is but an aggregate of minerals, it becomes evident that the character of the rock is determined by its mineral ingredients.

2. Chemical nature of the rock, particularly in regard to solubility. Solubility is at once both an advantage and a disadvantage. A moderate degree of solubility, when precipitation of the soluble portion takes place within the crushed rock, yields marked binding qualities. A high degree of solubility speedily weakens the stone and renders it unfit for road use.

3. Coherency of the rock. In igneous rocks the coherency depends upon the extent of interlocking of the crystals, while in sedimentary rocks it depends upon the degree of cementation of the grains. The coherency of a stone gives rise to the quality known as toughness, which is a necessary attribute of any stone designed for highway purposes.

4. Porosity; a characteristic due to pores among the original water-worn fragments of a sedimentary rock, or to steam holes in an igneous rock, caused by an original overplus of water. In general, as the degree of porosity of a stone increases, its value for road purposes decreases, because of a decline in its specific gravity, a lowering of its crushing strength, and a greater liability to the disruption of the road by frost action.

5. Texture, or the size of grain which composes the rock. As the size of grain increases, especially when the stone is made up of minerals widely different in their coefficients of expansion, the stone is more readily disrupted through expansion and contraction. This

would happen particularly in a region where rapid changes of temperature were common.

6. Fracture, or the appearance of a broken surface of the stone. Of the several fractures the conchoidal, which characterizes basalt, is the one most helpful in increasing the binding qualities of crushed rock. In paving blocks, the cubical fracture is the one yielding most economy in the preparation of the stone.

7. Joints, or the natural breaks possessed by the stone. They are generally in excess at the surface, and decrease with depth. When they occur with proper frequency, they are helpful in lowering the cost of quarrying the stone for crushing, but if too frequent may be detrimental, when the stone is desired for paving blocks.

In applying the principles above set forth, and in searching for "the everlasting better," we might say, in conclusion, that the ideal stone as road metal should possess these characteristics:

A mineral composition insuring sufficient hardness for complete resistance to any reasonable load; a chemical composition affording soluble ingredients only to assist cementation; a coherency giving the stone such a degree of toughness that only enough breakage will occur to give the road a maximum smoothness; a porosity of the least degree; a texture such that the grains or crystals will be of microscopic dimensions; a fracture yielding conchoidal surfaces and sharp edges; and no more jointing than that necessary to enable quarry operations to be conducted at the least expense.

It may be said that no stone possessing all these qualities can ever be found. While this statement may be true, it does not release us from the obligation to select that stone which holds these virtues in the largest degree. If I may speak of the state of Washington, I will say that we have stone which we believe will fulfill the most rigorous requirements as road metal, and it is our ambition at some succeeding Congress to show such results in the way of macadam roads that you will assure us that by our good works we shall be known.

DISCUSSION.

Mr. R. H. Thomson: I would like to ask Professor Landes if he has found any sandstone which he believes fulfills the requirements for macadam or paving blocks which is in reach of Seattle.

Professor Landes: I would like to say that, as far as paving block is concerned, Mr. Thomson is my master in that respect. I yield to him. As far as macadam is concerned, the only thing in the nature of a sandstone that seems desirable to use is one that is technically not a sandstone, but has passed to the succeeding stage, and is therefore much harder and more durable than a sandstone. We have found rock of this character that will be serviceable.

Mr. Thomson: I will say we do not claim to have mastered the sandstone paving block yet. We use the best we can get, but when we can get a better the city will welcome it.

Mr. Samuel Hill: We believe we have found a Superior sandstone in the state of Washington, an analysis of which is being made by Professor Landes. The stone has a crushing strength almost equal and identical with Quincy granite, being 21,000 pounds per cubic inch. It is about 96 plus pure silica.

Mr. Samuel Hill: I now have great pleasure in presenting to you Mr. Campbell, whose reputation is known to you all. We are very fortunate in having him with us to-day. I have tried to get him before, and I now have the greatest pleasure in introducing Mr. A. W. Campbell, of the province of Ontario and city of Toronto.

Mr. A. W. Campbell was down on the programme to give a paper on "Successful Macadam Roadways with Clay and Stone Binder," but instead gave a most valuable and interesting extemporaneous address on the system of road building in the province of Ontario. Mr. Hill, however, secured a copy of Mr. Campbell's paper, which will be incorporated in this report.

Mr. Campbell, who was received with cheers, said:

I consider myself very fortunate to have been selected as one to represent the Dominion of Canada and province of Ontario at this Congress of Road Builders, and I am delighted to be here with you to-day. It is not the first time I have had the privilege of attending such a conference and of having heard valuable papers read, which have been of great benefit to me in my work.

The subject assigned to me is one of a somewhat technical character, but along the line of the paper just read. It does seem as if the experience of the American continent, extending over the last few years, has reduced the question of stone roads to almost a science, which is understood now by most engineers, and there are very few points upon which we differ. To prepare the material and to lay it in a practical way are questions which we have to consider in connection with the varying conditions of climate, of soil, etc., and very often, while we have an ideal stone found within a state, we find it is more economical to use less valuable material, because of its being more accessible. However, I think that as a general thing engineers are reaching the conclusion that the principles of stone road making or how stone roads should be made to withstand the climate on this continent are to be yet established. How to prepare the public mind for going into a scheme of financing the making of stone roads, or roads of better quality, seems to me to be the ques-

tion of greatest importance, and one which I think must in the first place precede the actual specifications of how a road should be made.

A few years ago, in the province of Ontario, the Government established a Bureau of Highways in connection with the Department of Public Works, and it is the mission of that department to go about meeting with the rate payers in every town and village and township and municipality, for the purpose of discussing with them what system they should employ for the raising of the money and the performing of the work. In the province of Ontario, our municipal government consists of township councils and county councils. Our province is divided into townships, consisting of about 10 miles square. These are grouped into counties, comprising from 6 to 12 townships, and the county council is composed of representatives from the township councils. Up to a few years ago, the roads in each township were under the jurisdiction of the township council, and they had charge of these roads. The roads were made and maintained by what we call a labor tax, or statutory labor tax—so many days of labor taxed against the holding according to the assessed value of each. These men were supposed to turn out and perform such work as they were directed to perform by the overseers or pathmasters or road commissioners. In the early days, when labor was plentiful and money was scarce, the farmers had days instead of dollars, and this tax was imposed and worked pretty successfully. The people united themselves in large gangs, and were usually directed by the most capable of their number. This seemed to be sufficient to clear the road allowances of timber, and take out the stumps, and strengthen the weak spots, and all that sort of thing; but we have passed that stage now, and have come to the stage when some better class of work is necessary. We must look after the hardening of the surface of these roads, and must gather this labor together and direct it in the selection of the material, in the assembling of the material, in the crushing of the material, and in preparing it and applying it to the road; and we then find that that labor tax is incompetent, incapable, and practically useless, so far as the balance of the work on our roads is concerned, and consequently it is necessary to create throughout our province an agitation showing the people where their labor was being pretty largely wasted; for all that it was possible for them to do was to fill in the ruts and depressions in the earth roads, and the repair was of very little substantial value, having to be repeated each year, and consequently they were making very little progress, notwithstanding the fact that a great deal of labor was being expended on the work. Councils in addition had gone on to raise by direct tax a certain amount of money to be united with this labor, and that in some way was scattered.

We found, and the people found, after the agitation was put properly on foot, and statistics made and prepared, that we were spending 1,100,000 days of statute labor, and in addition the people were taxing themselves a million of money, and in no instance could we find a solitary road, which we would consider a first-class road, was being built. Our people could not in this way equip themselves by

any possible means with the necessary implements and machinery that is so essential to the building of a proper macadam road or the building of a substantial street. They went on doing work without the necessary tools, and consequently we find this labor and money represented a very, very large outlay in that province, and the agitation was in favor of commuting the statute labor and substituting a money tax, whereby the whole expenditure which was being made could be consolidated and concentrated upon some fixed plan, leading towards the construction of at least a certain mileage of road each year. When the people realized their expenditure meant so much, and that this capitalized would secure for them such a large amount of money to be laid out in substantial work, with roads built on scientific principles, when they realized what a first-class macadam road was, and what it cost, and that it could be made by themselves with the exercise of a little prudence and judgment, and the use of material that was easily available, they began to think there was no use in continuing that system of patching and repair; that the time had arrived when they should lay down some definite plan, under the direction of some experienced and competent overseer; that they should equip themselves with the necessary implements in each township and locality; that they should concentrate their expenditure, and commence at certain points on leading roads first; that they should follow this, making the most of their expenditure each year in building, if only a few miles, and extending that year by year. The result was that applications were made to the Government, to the Department of Roads, for the construction of sample pieces, in some cases a mile and in others half a mile, and as a general thing the money was subscribed by the people of the locality, assisted by grant of the municipal council, for the purpose of breaking down the prejudice that existed among the people against road construction. They seemed to fear the estimates that had been made to them that macadam roads would cost $3,000 or $4,000 a mile and in figuring this on a basis of the road mileage of each township, 100 to 150 miles, it seemed to frighten them. That to a township seemed to be too large an expenditure.

After the agitation had gone so far as to convince the people that the movement for better roads, for good roads, did not mean the bonding of the province for the purpose of raising a large sum of money, but that it did mean the directing of the public mind towards a more careful study of road making, how roads should be made, and what implements should be used in their construction, what materials, and how the materials should be prepared, and how applied, what a road would actually cost, how the money could be raised, and all this sort of thing, the people began to look upon the question of road making as being the most important public work with which they had to deal. They took a pride in each locality in the first half mile constructed, and were anxious for the next year to increase it to a mile, and after that first mile was built, and they saw some of the advantages of it, it was an easy matter to lay down a plan for the extension of this, until the attention of the Government was attracted to the interest which the people generally

were taking, and they were prompted to encourage them by saying that, wherever the county council, an aggregation of the township council, would lay down a plan for macadamizing the leading roads in that county, the Government would contribute one-third of the cost of construction. This offer of contributing one-third of the cost seemed to have stimulated the interest which the people were taking in the matter, and there was a desire to get the Government grant. This was never made for the purpose of trying to pay a debt which the people could not pay themselves, but for the purpose of stimulating that interest which had been raised by encouraging the people and leading them to believe that the Government was anxious to stand at least a third of the cost if they themselves would put up the two-thirds. That applied to leading roads. The county councils started in. Meetings were held in township halls and schoolhouses throughout the country to explain to the rate payers how the work could be carried out, what the work would cost, what the intention of the county council was, how they were going to raise the two-thirds, and how the people would benefit. Different schemes were devised for raising their two-thirds of the money; for the Government said: "You can do as you see fit as to that; bond the county if you will. We give you permission by this special act to raise up to 2 per cent. of the assessed value of the county for the purpose of meeting your two-thirds of the cost, and as the work progresses we will pay the one-third of the expenditure. The work must be done, however, according to the plans and specifications laid down by the Department of Public Works."

Five years have passed along, and county after county has fallen into line. It was surprising how difficult it was to break down that prejudice the people seemed to have against the Government interfering in any way in this connection, as to the county councils taking over any of these roads, as to there being any interference with the local management and control of the highways, and it looked as if they considered that there was something behind all this that was going to deceive them, and that they were going to have taken away from them the privilege of working out their tax. They required a little coaxing to get them to abandon this system. It came to this that it was looked upon as being an honor of the very highest order to be selected as pathmaster, or road commissioner, or road overseer. It looked to be as if the honor were of the more importance, for the reason that the man had the say as to what his neighbors should do in working on the road. In many cases the people became sufficiently interested in the work of improving the road that they united for the purpose of making a piece of road. They adopted the latest particulars of road construction, and worked enthusiastically and well, and it seemed to be their ambition to keep up that section in the best possible condition. But this was only about 10 per cent. of the communities in each township that cared to do it. The other 90 per cent. seemed to be indifferent. They looked upon the working out of the task as being a sort of national holiday, in which they could discharge their obligation without doing any particular work, and it seemed to be the height

of impertinence for the Government to interfere with the existing state of things.

I have frequently gone into meetings in townships and rural districts, where it was almost impossible to get a chairman to act, where some one would say: "You must be pretty brave to venture into a place of this description, and it will be a mighty fortunate thing if you are not thrown out of the window before the meeting is over." This prejudice has been broken down. We found that one of the greatest benefits to result from the agitation for good roads was the starting an agitation for the betterment of the highways, and then go out and educate the people along the simple lines of road construction. It is surprising what ignorance prevails in the rural communities as to the real principles of road making, and it is also surprising what carelessness exists among them as to how the work should be done. Indifference seems to be responsible for it. Some farmers are studying in the most scientific way how best to till the soil, to drain their land, to select with the greatest care their seeds. They have the greatest desire to have good barns and homes and buildings. Their ambition seems all to be along those particular lines; but they never thought it was worth their while, or was any of their business, to study closely and scientifically the matter of road construction. They understand the principles of drainage in connection with road making; but they look upon road building as being a matter that belongs to the township councils, or to the President of the country, or to the King and Queen. It is the King's Highway with us, and consequently it is somebody else's business, and not the property of the general rate payer, and he does not consider there is any obligation imposed on him to go out and organize for the purpose of improving the road in front of his own land, which he has by his own individual effort so splendidly improved. We have been trying to educate the people along these lines. It appears as if the first thing that is necessary to be done, before trying to educate the people in the principles of road making, is to unteach them some of the things which have been taught them as to how roads should not be made. It appears as if they do the very things they should not do, and it looks as if they consider the question of road making as a problem that is understood by engineers, and as soon as an engineer attempts to suggest to them how the work should be done they persistently refuse to accept the proper methods, and will go and spend time and money in doing the opposite.

The people will frequently say to me: "Well, tell us what are the principles of road making." And I say: "The principles of road making are simpler than what you think." So far as I am personally concerned, after an experience of fifteen years, devoting my time exclusively to the building of streets and roads, I have reached the conclusion that road making, or the principles of road making, are three in number, and three only, and that these principles are as simple as A, B, and C. The first is *drainage,* the second is DRAINAGE, and the third is DRAINAGE. (Applause.) DRAIN and FOUNDATION. Unless a foundation is thoroughly

drained, it is as useless and fatal for you to attempt to make a good road on that foundation as to put up this building on a weak foundation. The foundation is practically the substance of the road. It is the clay, the sand, the natural soil, that carries the load; and it is that natural soil that must be treated, and if that foundation is not thoroughly drained, then it matters not whether you put gravel, or broken stone, or vitrified brick, or asphalt. That road will be defective. The frost acts on the moisture in the foundation, and raises it, and if it is a macadam surface the course is raised up, and when the frost goes out the bottom is honeycombed, the course raised up is raised up on an unstable foundation, and the road cracks and splits, and the destruction of that road is commenced. The foundation must be thoroughly drained, and that is necessary, whether it is to be a macadam, or a vitrified brick, or an asphalt pavement. That drainage is absolutely necessary for the betterment of all earth roads, and with us, while we are making considerable progress along those lines, it will be many, many years before all the roads in our province, or in any of your states, will be macadamized or covered with stone. The earth road, for ordinary purposes, will be the public highway, generally speaking, for a great many years to come, and it is surprising what an improvement we can make upon ordinary clay or earth roads, if care, caution, and proper principles are applied to the shaping of the road, the draining of the road, and to keeping the road from year to year after the spring season has passed.

We started in to show how earth roads should be made. We started to show what these principles were and, as I said, the first principle of drainage is to drain the foundation, to make it hard and unyielding, to shape the road so as to shed the water out from the center to the ditches, to make the ditches along the side, or the gutters with a uniform slope leading to some outlet and to make the outlets through the adjacent property as near as possible. Cover the surface of the road with some hard material that prevents the earth rutting, that will withstand the traffic and prevent the wear.

We classify our roads into three classes: (1) Leading roads, carrying from county to county to a central point, which are subjected to heavy traffic, and which are made more expensively than other roads. (2) Those roads used only by a community, leading onto the leading roads. This class of roads does not require to be treated in such an expensive way as the roads with heavier traffic. (3) One-third of the roads are back roads, that lead into little settlements, used in many instances only by one or two farmers to reach other roads.

We adopted the plan of encouraging county councils comprising the larger area to lay down these roads passing through the different townships, making as far as possible a connecting system of leading roads in that county, and in approving the plans we compared the plan favored by the adjoining county with the plan of the county that had been adopted, so as to see that the plans would make a connecting system between the counties, and the leading

roads are the roads we attempted to aid in construction. Now fifteen counties, about one-third of the organized part of the province of Ontario, have already in hand the operation of that connecting system, and nearly three thousand miles of first-class macadam roads have been constructed.

Mr. R. H. Thomson: What is the soil?

I may say about half of these counties are a flat clay soil. Stone, limestone, granite, and trap are to be found in about half of the province; some sandstone and drift boulder are to be found in other parts. We have adopted the plan, however, of using the stone that is most convenient within a reasonable cost. In most instances we are not using the stone of the very highest quality, but in that case we understand that the cost of repair will be considerably more than if we used the better quality stone; but, if we have the freight to add on the long distance it has to be hauled, the cost becomes so great as to make it almost prohibitive, but we believe, using the cheaper class of stone, we will soon convince the people of the wisdom and importance of improved roads, and later on it will be less difficult to have these resurfaced with a better class of material. However, there is no doubt, from a careful study of the problem, that it will be money well spent to use the ideal road material in the first instance, when you consider the question of cost; but, as I say, you cannot bring about this by any revolutionary measure, but rather by a voluntary measure. We must establish object lessons, and gradually improve our plans and guide our people into the adoption of the better class of work, until we have reached the ideal. But progress will be slow along this line, and it will be some time before we can convince them of the economic value of using the most expensive material in the first instance. We are striving, however, to that end, and, in connection with the School of Practical Science of the Province of Ontario, samples from every municipality are sent in and tested free of cost, and returned to the engineers or road commissioners of municipal council. That department of the University is devoting a great deal of attention to this matter, more particularly in the towns and cities, where the millions and millions of money raised from the people by the cold machinery of taxation are simply spent, squandered, and buried in mud by the hand of ignorance and inexperience. As I have told the people, the time has arrived when they should look upon the question of street improvement as one of the most important branches of the public works of cities and towns, and that care of the highest order should be employed, and all the agencies of the Universities should be brought into operation to save the people from that awful taxation through which they have been passing in connection with the paving of the streets of their towns and cities.

I often think that principles more reckless and more extravagant are practiced in connection with the streets of towns than with the roads in rural districts. The towns are the centers of that, and they should set the example. They should establish the object lessons for the benefit of the people in the outside districts.

However, we are paying particular attention now to the improving of the rural roads. We have 3,000 miles of these roads now connecting, as a general thing, so as to form a line across the whole district of fifteen townships, which have been laid down, and this work has been completed, and these very councils which were the first to adopt the plan are now pressing the Government for an extension of their plans to permit them to lay down a greater road mileage. It is surprising how contagious it becomes when people get the disease of road improvement, when they see good roads made how remarkably easy it is for them to finance the problem, how zealous they then are to stretch out and extend that improvement. The counties that came in first, that have made the greatest expenditure, are now the counties that are pressing the Government the hardest to make that act more liberal, so as to permit them to bring in a greater mileage of road. It is a contagious disease, this matter of road making. It stretches out every day until it gets hold of people, and when it gets hold of them it is surprising how it clings to them. The farmer believes that the road in front of his place never could be macadamized. It is such a herculean task he could never think of bearing the cost of having it macadamized; but after it has been stoned, and he has paid his tax, he forgets all about the cost per mile, and he is living in luxury. He does not understand how it was brought about; but it was through some machinery of the Government, some plan of the Government that these leading roads should be improved, and that has led to the macadamizing of these particular roads.

We do not go into expensive paving. We use the material that is most easily available. We use rock crushers for crushing the stone. We have regular outfits that belong to the county council, managed by the county road commissioner, and the provision is imposed by the Government that, wherever a county plan is laid down by the county council, they must select a competent road commissioner to take charge of the work, and to see that the plans and specifications of the Government are carried out. One-third of the cost of that commissioner is paid by the Government, although he is a county commissioner; then he is approved by the Department of Public Works as being a person competent to carry out the plans and specifications of the Department. This was objected to in the first instance, until they saw that road making, the business of road making, takes years of training to prepare a man for the position, and that it was to their interest to have an expert, and one of the greatest benefits resulting from that is that the work of that expert is studied by the people in that community, and everything he does is watched by the farmers, by the local road commissioners and councilors, and they see how he does the work, how he operates the machine, how he grades the roads and prepares it for the material, how he prepares the material, how he places it, how he rolls it, and how he finishes it, and that object lesson we consider one of the greatest benefits the people will receive in connection with state aid.

Not more than 10 per cent. of the roads fall in the county scheme. The remaining 90 per cent. of the roads remain in the hands of the local councils, so that you can see that it is only a small percentage of the roads that the Government aids in the construction of. But these examples stand there to influence for good in the making of the 90 per cent. remaining, and we find that the benefits resulting in this way repay the province and make it one of the most profitable outlets they can contemplate. Example is a wonderful thing. Now, in our timber districts, of course, we used to use timber for making the culverts and sluices and small bridges. Since the adoption of the Government measure, we have prepared plans and specifications for the making of the sluices and culverts along the roads of cement concrete. Cement concrete is put along the small roads, cement concrete arches reinforced with steel being used in the larger roads, and in everything done on these roads we insist that it must be done in the most substantial and finished way. Where these culverts and sluices are necessary for the drainage of the land, they will be required as long as the community exists and the roads are there, and consequently economy dictates they should be built in the most substantial and finished manner.

A few years ago, people used to think that this class of construction belonged to European countries, and that the work was undertaken either for embellishment or for certain purposes of defense, but that the cost was so great that it was impossible for them to undertake it. Now these commissioners on county roads where state aid has gone see how easy it is to make cement pipes. They take the materials and things with them, and select the material and manufacture the pipes on the ground, and lay them down, and the farmers will come out and sit on the bank of the ditch, the elder ones, and sit and marvel at the ease with which these pipes are constructed. They see them laid in the trench and covered over, and the walls made to protect the pipes from the wash and other destructive agencies. Then they go along and put up a cement concrete arch, and the commissioners will at some time during the construction of the arch come and watch the operation. Those who have to do with that work on the lateral roads in their own district will sit there by the hour, and the commissioner and all connected with the work have positive and definite instructions from our Department to see that every question asked is answered, and the greatest care is taken to show the people how the thing is done, and to give them the fullest information. These men watch, and go back into their own districts. They say, "That is easily done; I can build an arch," and they go back, and where it is necessary they can get copies of the plans and specifications and go out there, and if it is necessary and convenient for that commissioner he may send one of his men to give some assistance and instruction and direction. These are only in the initiative; but, where a township is commencing for the first time to do work of that kind, we try to instruct them along that line. A local road commissioner, pathmaster, or local council will undertake work of that sort, and carry it out to a successful completion, and will boast of what they have

accomplished, and will take the greatest pride in pointing to this work as being a fine piece of work done under their management.

That sort of encouragement does more than anything else to stimulate the councilors to better work, and to show them that they should take greater interest in this municipal road work than they have done in the past. Encouragement is a wonderful thing. It is a stimulant, and that is what is required more than anything else, because the people of the community see that the common highway is their property, and that they are the people who should look after it, and that they are the ones who must look for the improvement of the roads, if improvement is to be made in this country.

The stone would be broken and screened into four different grades, from 2½ inches down. In early practice we used to figure on building about 12 inches, placing about 12 inches of stone on the roadway, varying from 8 feet in width to 16 or 18 feet, and as one approaches the towns the width and fill of stone depend upon the extent and nature of the traffic on that road. A road lying near a large corporation or center requires to be paved from ditch to ditch, or on a street from curb to curb; but as we get to only a single line of traffic 8 feet wide and 8 inches deep is sufficient. In early practice we followed the plan of laying 12 inches of stone; first 6 inches of coarse stone broken to 2½-inch mesh, and then about 3 inches of the next grade, broken to about 1½-inch, and then about 2 inches of stone broken to three-quarters, and then we placed on this about one inch of stone dust. This was a specification that was looked upon as being a very good one; but we have changed that somewhat, and our experience even now is causing us to change these specifications, and I do not know when the ideal specification will be reached. We think we have reached it; but experience suggests some little change from day to day, and we are continually making little changes, and I think it is a good thing for us that we are students enough to make the changes that should be made, because I suppose that this science on the American continent is only in its infancy. We do not appear to be able to get much assistance from the older countries. In the early days there were some stupendous roads built. They were built in a very substantial manner. They were certainly built in an excellent manner; but in this country of such long distances it would be impossible for us to hope to follow their pattern, and we have to figure considerably for ourselves.

I believe that it is good practice to work the heavier grade of crushed stone as nearly as possible to a wearing surface, and I think it is advisable to place the stone on in layers of not more than 6 inches without rolling, and that the fine dust screens, instead of being placed on top, should be dusted into it, to fill the voids through the whole construction of the work. It is impossible for us to get that perfect consolidation necessary by rolling entirely from the surface. It is difficult to make people believe that a road is heavy enough, if we do not give an impression that the road behind is as firm as solid rock. I believe in using a light roller, about 10 tons in weight; but that should be used as often as possible during

the whole construction of the road. Keep sprinkling the stone and rolling it in, mixing with an amount of fine sand. Do not dump it on the surface of the road, but take it out of the cart with a shovel and sprinkle it where necessary. It is slow work, but it is the only way to get the perfect instrument that is required.

Care must be taken to see that the stone is of uniform size if you want the road to wear uniform, and, more important still, that the stone is of uniform character. Then see that every block is keyed in its place, and enough binding material to pack it, and see that every void is filled, and roll it until it is thoroughly packed and brought to an even surface. Never make the stone thicker in one place than another; never leave depressions to be filled with a greater thickness of stone; otherwise you will get an un-uniform surface. Bond the first course of macadam; bond every course, and roll every course until you have the stones set in place, and sprinkle with water, so that the bonding will be carried down; but do not sprinkle so much as to wet the earth underneath the roadway.

Question: What would be the cost per mile?

Mr. Campbell: It all depends upon the availability of the material. They cost us from $1,200 to $3,500. If you are building roads along this plan, then these implements are necessary, and it is necessary to have men who are capable of operating them. I have seen implements used on roads, where the people are simply sent out at so much a day to make the improvement. With implements so directed, sides cut off the roads, and stuff piled in that should never be put there, whether the roads were stone or gravel originally, and the shoulders had risen so high as to prevent drainage, these were cut off, and stuff brought in and placed on the top of the old road. There is a lot of that weak material to be found on every road that should not be put in, but cut off and turned out. Many times you will find the operator of the machine who sees a road to be rounded to a certain course, and he simply carries out his instructions and becomes a part of the machine himself. The man should be a skilled workman, a mechanic that not only understands his machine, but the purpose for which the machine was designed, and he should use some skill and brains in the operating of it.

The road grading machine is one of the most economical instruments ever invented for the purpose of bettering roads; but in some instances it would be better for a community if they had never seen a grading machine. Roads are injured rather than bettered; but that road machine has no brains, and knows no more about road making than I do. (Laughter.) It is used for a purpose, and unless operated by somebody who does understand road making, you had better be without the machine.

I have brought the question of macadam roads down to this, and it is very little use for me to say anything about this, because the paper we have heard covers the ground completely. It deals with everything there is to be said about it, and consequently I hesitated to read my own paper, because it is repetition, and for that reason I started to do some talking, and forgot about the pa-

per. As I say, the whole subject is boiled down to the preparation of the foundation that must be made, and in some instances it is easily made, because the material is loose and easily drained. In other cases the material is wet, soft, and soggy, and that must be drained. In mountains and hilly districts, it is very difficult to provide these side water beds; but it is just as important in rocky, mountainous districts to provide for the carrying down of the water, because, if you do not provide for the carrying away of the water, it will wash away more or less each year, until the road is made rough and impassable. The foundation requires the first attention, and then prepare the stone. I have known roads where it has cost $5,000 to make the foundation for a mile. There are instances where roads must necessarily cost an enormous amount of money. These are the worst spots, and if you cannot touch the rest of the mileage, if it costs $10,000 for the one bad mile, spend the money on that one bad mile, and leave the balance of the road in general fairly good condition.

We must choose or adapt ourselves to conditions as we find them, and the question of cost is something. A railroad company will go to build a railroad over a prairie district; but you cannot compare that with the cost of the system that has to be built through a mountainous district. They try to lay down a system that will serve the community and make the connections they wish to make, and then they go to build the road and try to find the necessary money for building it. That is about all that can be done in connection with roads. To estimate the cost per mile is misleading, because in one township you may build for $1,000 a mile, and in an adjoining township it may cost you two or three times as much, and in another part of the county it may cost on some miles as much as $10,000. We cannot very well speak of cost per mile. If we simply say, "What is the cost per mile and where will we get the money?" we will never have macadam roads.

We have sections to-day that have originally been covered with the heaviest class of timber, and when the early settlers came in, about one hundred years ago, they had some reason for asking, "What will it cost per mile?" They had no money but strong arms. They had the brain and determination, and these men went in, they cut down the trees, they grubbed out the stumps, they corduroyed the swamps, they bridged the streams with their own labor, without the assistance of one dollar from the municipal or government treasury. If these men had said, "What will it cost per mile?" "Where will we get the money?" this continent would still be a wilderness, we would have no roads. But they said and knew that roads are of the first importance in connection with settlement. They said: "It is no use asking what it will cost per mile, and where will we get the money. It is necessary we bind ourselves together in the possible bonds, and labor intelligently under the direction of our best and most brainy citizen." They cut down trees and labored hard, with the result that we now have in nearly every state and province of this continent our road allowance cleared and graded to some extent. What remains is for us to commence and form roads, form the roadbed, and put on some material

that would put them in a finished condition; and it is useless to consider cost per mile, but it is necessary for us to commence on right principles and work back, so that the labor and expenditure we are now making will produce a dollar's worth of road for every dollar spent on it, a dollar and a half of road for every day of our labor that is spent upon it. It is time we wakened up and gave that system of labor and labor tax the credit to which it is entitled. It has performed its labors. It has done the services for which it was designed, not only for this continent, but every other continent, in the early days. But it has outworn its usefulness, and it is cruelty to ask it to perform the service of macadamizing and finishing the roads that it was never intended to perform. Give it credit for what it has done, and let us pass on, and revise our methods, and adopt a policy that will benefit all of every state and province on the continent by the improvement of their roads.

Who have fixed these roads and brought them to their present condition? The farmers of the states have built the rural roads, but the people in the towns and cities see what they are doing. Is it not a marvel to come into this state of Washington, and city of Seattle, and see these splendidly paved streets. It is a revelation to me, after having visited cities that have taken generations and centuries upon centuries to improve in this way, to come for the first time to the Pacific Coast, and find this young town with its magnificent buildings and its road making in keeping with all. It is a pleasure and delight, and I have no doubt every person in this state takes a great delight in coming here and seeing how this has been brought about.

How about the roads in this city? Let this be typical of every state of the Union. As a general thing, we find, while cities and towns have made wonderful strides in this connection, the people in the rural districts have not. I have wondered, in thinking this thing over seriously, how it comes that this tax or obligation of the making of roads in the rural districts should have been imposed on the farmer, and the farmer alone. Why is it that the people of the country should build the roads to bring the produce of the farmer, of the mine and factory, into the city and market, and to bring the goods of the merchant and manufacturer back into the country, any more than the people of the cities and towns should have been obliged to build roads into the district to scatter their goods and wares and bring the product of the farm back into the town.

Gentlemen, it is too much to expect that the farmers are going to keep up all these roads and make them or bring them to that condition which the commercial requirements of the country demand they should be brought within. The assistance and co-operation of the people of the towns and cities is the only one fair way of bringing this about, and that is to have the tax imposed in such a way that every member of the community will contribute toward the building at least of the main roads leading out through the country. Every merchant in every center will benefit as much as the farmer that is served. There must be some co-operation; otherwise it will be impossible to get these roads brought to this

condition. There must be a state tax, in my opinion. We found that the people of the towns and cities were willing to help the farmers, and were willing to be taxed with the people of the townships and rural districts to bring about these better roads. The question has always been looked upon as being too commonplace, and the brainy men of the country never thought it worth their while to devote their attention to the commonplace question of how to make and keep the roads. That has been lost sight of. Let it be looked upon as one of the biggest problems of the community, and we will arouse public sentiment and have legislation that will be fair, just, and equitable, that will bring about this improvement, and every member of the community will benefit, whether in city, town, or county. What would be the good of the country, if it were not for the transportation system? That is made up of railroads, the highway of the sea, and the common wagon roads. In the province of Ontario we have a regular network of railroads, so complete as to almost make us say that no other road will be necessary, yet there are only 8,000 miles of railroad and 60,000 miles of wagon road. Every ounce which is carried by railroad or steamship must pass over the wagon roads of the country. Close up the wagon roads of the country, and your marvelous system of railroads will starve in idleness, or the ocean vessels would rust at their moorings.

This is, then, an important question, the biggest end of the great system of transportation. I have for the first time had this opportunity of coming through these Western states, and have viewed something of your railroad system, stretching as it does from the Atlantic to the Pacific, built with a skill and daring that compels the admiration of the civilized world. These were not built in any haphazard way, but by the organized effort of brainy people of this nation. They got themselves together for the purpose of laying down trunk roads of the transportation system, and as a result there has been built a marvelous system; yet, when you come to count up, this is only a small percentage of the great transportation system that is necessary to carry the stuff from the farm, from the field, from the mine, to the markets of the world. The bigger end of the transportation system still has to be undertaken, to get the full benefit. Why was it that that particular individual who to-day in the public interest has seen fit upon this Pacific Coast to call for the first time a Congress of Road Makers, but that he realized from the experience he has had in the greater problems of transportation that the greater the improvement upon the lesser, the better for the greater. It is a man of this kind that you want to have at the head of your Association. You want men who do not see for the season, but see into the future, look beyond the sky line where the great roads go down. They are the men who are required in the western part of this continent to bring about these great improvements that still remain to be made, and I say in this connection that you have undertaken marvelous works and carried them to a successful completion. This question of the improvement of the common roads still remains to be taken hold of, and I think it is a sub-

ject for congratulation to find that such men as your present President and the University of your state have seen fit to take hold of this matter in the manner in which it should be taken hold of, and I believe in the next five years' time you will have an organization laid down here for the improvement of roads that will bring about and make the road improvement in keeping with the other improvements made in every other connection, and when we return here, if Fortune permit it, in a few years' time, we will have the opportunity of being driven over some of the ideal macadam roads of the state of Washington. (Cheers.)

Mr. Samuel Hill: I hardly know how to express the thanks of this Congress to Mr. Campbell. I have heard many addresses on the road question, but I don't think I ever heard an address that covered so completely the ground necessary to be covered on this topic. I might say that every paper presented here and every address given will be carefully printed and published as the last word on the question of road building to-day in this country in book form.

Mr. M. O. Eldredge: I would like to ask Mr. Campbell two questions:

1. In the drainage of the road in wet places and in mountain sections, do you ever use the subdrains or tile drains?

2. What method do you adopt in the Parliament of the Dominion in maintaining the state roads after they are once built?

Mr. Campbell: In answer to your first question, we adopt the system of side ditches or gutters for the carrying off the surface water. In clay of a retentive character we use subdrains of porous tile. In laying the tiles we find it is necessary to be very careful. We usually put sawdust or gravel underneath the tile, and cover this with coarse material, or material that will form a sort of filter, and attract the moisture from the road to let it readily into the tiles. In reply to your second question, the road is maintained by the county council that constructed them, under the supervision of the county superintendent. He goes over the roads, and our instructions to him are to maintain these roads, or repair them, by never letting them get out of repair.

Mr. Lancaster: Have you not built some roads of a thickness of 6 inches?

Mr. Campbell: Yes; many of them, as I pointed out. We look upon 6 inches of crushed stone properly applied on a well-drained

foundation as being just as competent for the third-class roads as 16 inches would be for the roads that have the heavier traffic.

Mr. Eldredge: Do you ask for state aid in the maintenance of the roads?

Mr. Campbell: No.

Mr. Samuel Hill: I agree with what Mr. Campbell says as to the foundation of the road. If you have the bottom right, you have everything right. Mr. Campbell has spoken about our streets here, and the man who made these streets is here to-day. He has a paper which it will take him about 16 minutes to read, and, as we have that much time before noon recess, I will ask **Mr. R. H. Thomson,** our city engineer, to read his paper on "Why and How Cities are Built."

Mr. Thomson, who was heartily received, said:

My paper is on an entirely different topic to that which has preceded it. It was produced by the very conditions which Mr. Campbell has indicated as having prevailed in Canada. In Canada it seems that the gospel of Good Roads is propagated by the Government. In Washington the gospel of Good Roads is promulgated by Samuel Hill. Last fall Mr. Hill asked me to go with him to a certain county seat in a very rich county in the state of Washington. I will have to admit that he used some little deception in getting me to go there. He thought that perhaps even I might not be brave enough to face the hostiles in that territory on the question of good roads. As we drove to the county seat, a city which aspires to be at some time a very great city, we were dragged through mud so deep that on coming to the crossing of the city streets it took two of us to lift the front wheels of the buggy while the horse pulled it over, and I was not surprised, after being brushed and washed, to find that I had been taken there for the purpose of giving an address on Good Roads. Neither was I surprised to find the people hostile to my interference, and at having people coming to them from other cities to tell them how to build roads, and they living right there. Knowing it was a difficult subject to broach, I started in with a little talk on how large cities grew, attempting to appeal to the pride of the citizens of that city, and get their co-operation in the matter of road building, and to get them to understand that good roads were the vitals and essence of success and that they must have good roads if they would grow. Doing that, we started away off, and approached them gently, and I am pleased to say we parted without any scars upon us, in fact, with the good will of the community, and Mr. Hill being pleased with the prelude, asked me to write it down and tell it to this Congress, so that others might have some similar means of making peace with their community.

HOW AND WHY CITIES GROW.

BY REGINALD H. THOMSON.

Gentlemen:

From the earliest dawn of history men have inclined to associate themselves together in those assemblages which we call cities. The purpose of the first city building is not clearly defined in history, but the purpose of the village is well understood. For many centuries the village was occupied by those neighbors collected together in close relationship one to the other, for the purposes of companionship and protection, so that from the beginning the village has been, to a certain extent, a camp or stronghold. Some of the large cities of the past were built at enormous expense for military purposes, strategic centers of military control having been chosen, and the city located with reference to its relationship to the territory to be governed. Other cities grew wholly from commercial enterprise, and it is this class which has endured through time, which continues to maintain its identity, and with reference to which I am expected to speak. The growth of such cities is, to the minds of many, an unsolved mystery, and they are frequently looked upon as accidental occurrences, and it is possible that there are some cities of considerable size for which the cause underlying their growth would be hard to determine. Nevertheless it has been well affirmed that commercial cities grow by immutable law, even though they may appear to grow by accident; yet, although they may grow by immutable law, as in every other thing in which man is interested, man can either aid or hinder that development which the law permits.

Under the law of the body, the heart drives the life blood into every part for its proportional and symmetrical growth; yet, as the result of disease or other disturbance, the arteries leading to the different parts of the body may become choked, and the flow of blood to those parts may be so diminished in quantity as to permit those portions so deprived of food to shrivel. Lack of food or impaired digestion also may cause the impoverishing or the wasting away of the entire body. In the same manner and to the same extent, the impairing of the arterial highways leading to, or those within, a city, or the permitting of unsanitary conditions to exist in or near a city, may cause its destruction, as similar conditions destroy the body.

For long ages it was impossible for the city, except under the most peculiarly favorable circumstances, to advance beyond the size of a village, or to exercise functions other than that of the village, as we now understand the term. During the greater part of the period of history there has been somewhere upon the face of the earth some collection of houses sufficiently large of itself to be styled a city; but this collection has usually been the seat of government, and as such was made and maintained, so long as it existed, by the forces which maintained the government. Follow-

ing the chronology of the ages, we find some periods in which no city of any size whatever is indicated. Possibly there was a city existing somewhere as a seat of government, of which the record has not yet been made clear. Some fifty or sixty years ago, in a discussion of this subject, the expression was used, "This is the age of great cities." Even at that time, the size of a great city as we now understand it was not comprehended, because the two great models of cities from which comparisons could then be made were Paris and London, and even at the time of making this remark London did not contain over a million and a half people, so that to the mind of speaker and hearer the thought of the age of great cities was the thought of an age in which there could be one or possibly two cities in the world with a population of a million and a half people, and also a number of a smaller size, some of which might aggregate six hundred thousand people in population. To make that same remark to-day, to wit, that this is the age of great cities, conveys to the minds of hearers a different impression, owing to the fact that they would immediately see in their mind's eye a vision of a city of more than six millions population, and visions of nearly a score of cities containing one million and over, and many more than a score of cities containing half a million and over.

Until recently there was manufactured in the village practically all of those things incidental to the life and the subsistence of its inhabitants, and for them only. Where more materials were manufactured than filled the measure of local necessity, those villages became cities and centers of trade. The number of such, until very recent times, however, was very limited, owing to the fact that the manufacture and distribution in each village was usually intended to be, and was, sufficient only for the necessities of its immediate vicinity. As we look back upon the long series of centuries during which this condition prevailed, we style those ages "the ages of the homespun," and, looking upon the conditions of the present, we find ourselves, not only in "an age of great cities," but in "the age of the wholesale," there being manufactured in one city all of the goods of a certain kind needful for and used by the inhabitants of many cities and villages. The change from the age of the homespun to the age of the wholesale was made unwittingly. In the year 1788, James Watt, with his partner, Boulton, after considerable effort, persuaded the proprietors of the Albion Mills in London to begin the operation of their mills with one of their engines, and, so far as we know, this was the first application of steam to actual manufacture ever made, and on the day that Watt & Boulton's engine first turned the burrs of the Albion Mills the gates were opened and the human race began to pass, as I have said, unwittingly and unconsciously, from "the age of the homespun" to "the age of the wholesale," and from that hour until this there has been an intensifying of conditions of every class and kind, dependent upon certain fixed laws. Philosophers have laid down the rule that in these days villages may still continue as friendly associations of citizens, and possibly as remnants of the

age of the homespun, but that cities grow only where there is (a) "Cheap Bread" and (b) "Good Sanitation," and, added to this, for permanence and stability, there must be (c) Stable Government and (d) Honest Tradesmen. Stability of government is necessary that there may be security to the investments made for the purpose of manufacture and commerce, and honesty of tradesmen must be had in order that there may be confidence in the breast of both producer and consumer; confidence on the part of the producer that goods committed to the hands of the tradesmen will be honestly accounted for, and confidence on the part of the consumer that the goods transmitted to them as the result of orders will be the identical goods designated in the bill. Admitting, therefore, that in a certain locality there exist the two latter conditions, "Stability of Government" and "Honesty of Tradesmen," we are still obliged to inquire as to the relationship which cheap bread and good sanitation holds, or may hold, thereto.

By "Cheap Bread" it is understood that in the given community the cost of living in comparison with the daily wage is for some reason less than at other points. This economy of living will in great measure be dependent upon the relationship of the locality to the various sources of production, and this relationship is dependent almost entirely upon the cost of transportation between the given city and the sources of production. There might be ever so stable a government and ever so honest tradesmen in a given locality, and they might be ever so zealous for the upbuilding and the development of their territory; but if there were no means of easy access to that city, if the highways leading thereto were such as to prevent the most economical delivery of goods to or removal of manufactures from its gates, it could not thrive. The highways, therefore, become prime, if not supreme, controlling factors in the growth of a great city. In the consideration of the highways affecting a locality, we must take into account the following:

1. The highway of the nations—the Sea.
2. Rivers.
3. Canals.
4. Roadways, such as public roads.
5. Railways.

There are some great cities not located upon the highway of the nations, the Sea, and which are not even easily tributary thereto; but we will find that they have generally been built as governmental centers and maintained under peculiar conditions. The great cities of the world, in the past and to-day, are those which have the most easy and the most direct means of access to the ocean, or are located upon some great inland lake or sea, or at the confluence of freight-bearing streams. Possibly the most notable modern example of the rapid development and existence of a great city supposed to be not located upon any great natural stream or waterway is Berlin. This city is often represented as having sprung from the barren sands of Prussia. A careful examination of its conditions, however, reveals the fact that this city, for its finan-

cial and commercial life, is dependent upon its highways, in part upon roads and railways, but chiefly upon highways of water; these, in this case, being canals. History records the fact that in 1640 Berlin had but about 6,000 souls, but that about that time Frederick William, by the construction of a canal from the Spree to the Oder, "caused Berlin to become an important center of foreign commerce and shipbuilding," and that he further laid the foundation of its prosperity by encouraging the settlement there, as the necessary "honest tradesmen" of the land, of Huguenot refugees from France, guaranteeing to them peace and tranquillity, so that, in the case of Berlin, its growth arose from its relationship to foreign commerce, and its stability of government, aided by honest tradesmen and good sanitation; but the vital life of its commerce has been, and is, dependent upon the cheapness of its water-borne freight—that is to say, its "Cheap Bread."

What might be deemed a favorable relation to the sea for the location of a city of to-day might be very different from what it was one hundred years ago. Probably until that day there had been no more favorable relation of the sea and land had by any city than that which had been enjoyed by those great cities which once flourished on the Mediterranean. About one hundred and fifty years B. C., there flourished near its shores Antioch, on the Orontes, Alexandria, Carthage, and Rome. Besides these, there were Tyre and Corinth, and others of equal or lesser size. Carthage boasted of 700,000 souls, Rome of 500,000, Antioch of 400,000, and Alexandria of 300,000. They lived and grew under the same laws of growth which we now affirm as governing city development. Each had access to the fertile fields surrounding the shores of the great inland sea. Each (for purposes of war, it is true) had builded magnificent roadways within their own limits and to far distant lands. Each had developed wondrous water systems and sewers, some of which remain until this day. They lived, each and all of them, under the law of "Cheap Bread" and "Good Sanitation," re-enforced by stable government and popular tradesmen. This was the first age of great cities; for of a truth we are now in the second age, and this age is dependent upon the successful harnessing of new, and to them unknown, forces of nature, all springing from and dating from the successful installation of the steam engine referred to above.

After the experimental stage in the use of the engine installed in the Albion Mills by Watt & Boulton had been passed, it became evident that, where steam could be used, enormous quantities of grain or other goods could be handled at one place and with much less expense; that is to say, that at that place there would be "Cheap Bread." To encourage the importation of grain and other raw materials from the rural districts to those places of cheap manufacture, canals were improved, highways developed, and the inventive genius of man presently brought forth the steamboat and the locomotive, each the bearers of burdens to and from the favorable centers of manufacture and distribution. For example, with the larger and more speedy vessels on the sea, and with the favorable

waters of the Thames as a harbor, and with the inland canals and macadam highways to and from London, it now had the opportunity to, and did, outstrip Carthage and Rome and the other cities of the Mediterranean in its manufacturing and commercial institutions, although giving less attention to other features of municipal life than did they. Death by plague and by other contagious diseases had in times past visited London with disastrous results, and to prevent their recurrence the mind of man was given to the solution of the problems of life, and as a result the laws of health were more fully developed than they ever had been theretofore, and as the population of the city grew the ability to continue in growth was safeguarded by this better and clearer knowledge of the laws of life.

The highway, however, which brings the freight to the city, is not the only one that is essential to its life and best development; but the means of intercourse between the various parts of the city must be made especially easy, so that freight which has been brought from afar, on good roads or by water carriage, at a minimum of cost, shall not have its value destroyed by the tax imposed in conveying it from the terminal of the long-distance haul to the place of manufacture. This requires the making of arterial high ways through the city, so as to bring freights arriving over any route or by any conveyance actually to the factory door at the least possible cost, both for the purposes of delivery and for the distribution of the results of manufacture. These arteries may be roadways, or they may be canals, or they may be railways. As a rule, for actual success as seen in the world's marts, there must be all of these forms of highways present, and suited to the carrying of the heaviest burdens at the least cost. None of them can be lightly neglected by those who would prevail. With these present, that is to say, after the freight has been cheaply delivered and the raw material is ready to be converted into the manufactured product, if the workmen be not strong and quick, if the vital blood of life course not freely through their veins, if there be some other locality, of reasonably equal position as to the handling of freight, where man's mind is more active and his fingers more nimble, that locality will certainly become the greater center of manufacture. These conditions of active body and active mind depend upon good sanitation. Good Sanitation is dependent primarily upon climatic, and secondarily upon artificial, conditions, which artificial conditions are equally, if not more, important than are the climatic. Every workman engaged in the battle of life must be able, as part of his daily food, to enjoy the use of a reasonable supply of good water. This is the first requisite of good sanitation; and, second, there must be provision for the immediate removal and proper disposal of the wastes of the body; and, third, as the final and equal prerequisites of the ability to maintain and to continue good sanitation, there must be in the city perfect streets and perfect drainage. I have referred to the great change made in Berlin, their first sewers having been built in 1882; death rate then 36 per 1,000 now about 16 per 1,000. As long as any city maintains filthy streets, it will be

subject to the recurrence of most deadly and appalling outbreaks of devastating disease. As soon as hard surface streets and fair sewers are laid down, new vigor comes to its inhabitants and the span of their lives is lengthened.

After a city has become established, the law of gravity tends to add to its population. There will be those who will be attracted thither simply because of its size, as compared with some other place had in mind. Others will be attracted because of the presence of congenial spirits; the more of the class, the more attractive to those of the kind. For instance, a coterie of artists will attract other artists, and so on; each group or class drawing others of their kind. This law of gravity works continuously and persistently; but the effectiveness even of the application of the law of gravity upon city growth is limited by its fulfillment of the requirements for "Cheap Bread" and "Good Sanitation."

The Good Roads Association specializes its labors toward making and maintaining good roadways. The value of such roadways is frequently computed purely with reference to the economy of the delivery of suburban or foreign products and general freight movements. Probably this resultant of a good roadway is dwelt upon more than any other, because it is believed that this particular view will appeal to the mind of those who must bear the cost and burden of constructing them more strongly than any other argument. I am not sure that this is the highest use of these roadways. They are the arteries of the community, and they cannot be maintained unless they be clean, and with every step that is taken toward developing the hard surfaces of well-prepared roads there is a step taken toward the higher physical, mental, and moral development of the community. It is an element both of Cheap Bread and Good Sanitation. It is an element vital to the development of the community, and they who are engaged in the advocacy of their construction are truly engaged in a warfare against disease, against poverty, against crime, and in behalf of health, vitality, and virtue.

AFTERNOON SESSION.

The first paper read at the afternoon session was on the subject of "The Farmer and the Road," by **Mr. F. N. Godfrey**, of New York.

In introducing his subject Mr. Godfrey said that great changes had taken place since the introduction of the automobile. He said:

When the automobiles first made their appearance on our roads, they frightened our horses; but the farmers have now come to recognize the automobile as any other vehicle, and our horses have also grown to recognize the automobile, and not to fear it, as they

did at first. A few years ago we would drive a horse out on the road, and it was actually risking our lives to meet an automobile; but to-day we take a colt out of the field, and he fears it no more than the people, sometimes not half as much.

Mr. R. H. Thomson: Is that due to the difference in the road surface, or the training of the horse? (Laughter.)

Mr. Godfrey: On account of the horses getting used to it.

Mr. Thomson: Not because of the improvement of the roads. (Laughter.)

Mr. Godfrey: I broke a horse to drive this spring, and it was a surprise to me when we drove on the highway that the mare feared an automobile no more than another horse or vehicle. She had no fear of the trolleys when we drove into the city. I attribute this to the horse being raised alongside of the highways and becoming used to it.

THE FARMER AND THE ROAD.

The problem of highways has probably concerned the farmers of this country more than any other class of people, inasmuch as upon them alone, for many years, devolved the building and maintaining of the roads. From the old tortuous wood roads, following the streams very largely, or a blazed trail over the hills and mountains, the corduroys and slab ways through the swamps and lowlands, to the present good and improved highways, graded and straightened almost to the grade of a steam railroad, the farmers have largely been the factor bearing the burden of expense, and therefore the ones most to be reckoned with.

In the early history of the country the blazed trail and first wagon roads were winding and long, often making the distance double that that now is, as the country has been cleared and the roads straightened and graded. As the country was settled and new farms were opened up, new highways were built without much thought as to grade and line, and to-day we have in many states, especially in the East, very crooked and irregular roads. Gradually the sentiment for better and improved roads has grown. The coming of the bicycle started the movement with greater celerity than any other one thing for many years. Then the arrival of the automobile has no doubt culminated in the climax of road improvement, by creating a greater interest with the whole people, until all are ready to lend a hand in the improvement of the highways.

The farmers at first have been loth to favor the more expensive improvement of the roads, believing the movement was largely in the interest of the manufacturer and users of automobiles; but,

be that as it may, as soon as an improved road is properly constructed through a farming section, the farmer is brought at once to see the value of it in the great advantage to him in the movement of his produce to market, and, since the whole people are assisting in the expense, we farmers are withdrawing our objections and are very willing to assist.

Taking up the improvement of the highways, let me emphasize this fact: That the market roads should be the first to be improved, thus bringing about greater prosperity to the country, by reducing the cost of marketing the enormous products of the soil, in lessening the cost of hauling to shipping points and nearby markets. Later the trunk lines may be connected up, to accommodate the wealthy seeker of pleasure in touring the country with the automobile. It is the laboring man, the great producer of the country, those who must use the highways every day of the year, whose interests must be looked to first if the prosperity of this country is to continue. The pleasure seeker, who uses the roads only during the summer months and for pleasure only, finds but little trouble now on the highways, even if only dirt roads, if they are contented in driving their machines at a reasonable rate of speed.

In the construction of the improved roads of the country I must speak more especially of those of my own state, knowing more of the situation there than anywhere else. Until about twenty years ago the construction and maintenance of the highways were almost entirely dependent upon the farmers and owners of property adjacent thereto; they being taxed at the rate of a day's work for each five hundred dollars of assessed valuation, the work in the different towns being under the general supervision of a highway commissioner, and subdivided into districts under an officer called the pathmaster, who ordered the farmers and those liable to road tax out to work the roads as time and convenience suited him. It was quite often made a sort of gala day for a round-up of the neighbors, with but little real work done. There were notable exceptions, however, where the farmers took pride in improving the road, gradually shaming those who cared but little for a good highway, till a decided improvement of the roads was becoming noticeable.

Then came the road scraper, first a square stick of timber with an old upright sawplate attached. This was an excellent tool for smoothing the roads in the spring and filling up the ruts. Then the wheel scraper or grader came into use, and in the hands of an intelligent and skillful man is an excellent tool still largely in use on dirt roads, but in the hands of the ignorant and unskilled does more harm than good.

About twenty years ago the law was changed so that corporations must pay a highway tax, which brought into the towns a little more labor on highways, that helped improve them.

Then came in 1898 the Higbie-Armstrong Act, which provided that the state should aid in building and improving such roads as the county and towns decided on, the state paying 50 per cent., the county 35 per cent., and the town 15 per cent., and about two thou-

sand miles of road have been improved under this act, called the "Bonding Act."

In 1903 the Fuller-Plank Act, providing state aid to such towns as preferred to change from the old labor system to a moneyed system, placing the work in the hands of the highway commissioner to expend the moneys devoted to this purpose as his judgment dictated. This act provided for the payment by the state of fifty cents on each dollar raised by the towns. This method has proved of great value in the greater improvement of the roads, as in the hands of intelligent men selected as highway commissioners a more uniform system was begun and carried out.

The Patrons of Husbandry, now well known and commonly called the Grange, having become a strong organization in New York, began to take an active part in directing legislation in the interest of agriculture, began to study the road question, and, feeling that the laws along this line could be improved, favored the placing of the improvement of the highways in the hands of a commission, instead of under the direction of the State Engineer. I ought to have said that the Higbie-Armstrong Act provided for the bonding of the state for fifty million dollars to the improvement of the roads. In 1906–07 the Grange prepared and introduced amendments to the Armstrong and Fuller-Plank measures, providing for a graduated scale of assistance to the several towns of the state according to the assessed valuation per mile of the highways the town contained. These measures were found practicable and valuable, and were passed and became laws. It was found at this time that the Bonding Act was unconstitutional, and that no one would take the bonds of the state for the improvement of the highways. So the Grange came to the rescue by preparing a bonding bill which was declared sound, and this was passed by the same Legislature and received the approval of the Governor. At this time it was thought best that a committee of the Legislature be appointed to investigate the highway situation and report to the next Legislature. Such committee was appointed, and in their report they advised a revision of the highway laws, which was done, at the next session, that of 1907–08, recommending also a highway commission. The laws advocated by the Grange and passed were incorporated in the Revised Laws, and now the improvement of the roads of New York state is under the direction of a highway commission of three members, appointed by the Governor in January, 1909. The commission thus appointed is required to select and appoint two deputies; the duties of the first deputy being the care and maintenance of improved roads, and the duties of the second deputy are the care and supervision of unimproved roads and the highway bridges of the state.

There are about 80,000 miles of public highway in the state of New York, and not to exceed 10,000 miles can be improved under the fifty million bond issue. Seventy thousand miles must, therefore, be improved by the towns, with the aid of the state, under the direction of the deputy in charge of the Bureau of Town Highways. The appropriation by the towns for the maintenance of these 70,000

miles of public highways, or the amount of money raised by tax in the towns for the maintenance of these 70,000 miles, is about $3,500,000, and the moneys paid by the state to aid the towns on the Grange plan is about $1,500,000. In the care of earth roads the state is divided into 9 districts, presided over by 9 district supervisors. There are 57 district or county superintendents of highways, appointed by the board of supervisors of each county in the state, making a second subdivision, and under the district or county superintendents there are 933 town superintendents. According to the best information obtainable before I left New York state, the second deputy commissioner stated that there are between 24,000 and 30,000 men and between 5,000 and 6,000 teams employed in caring for the earth roads of the state.

The annual cost for the repair and construction of bridges in the state of New York is about $1,400,000. The amount of money annually expended for the purchase and repair of machinery is about three-quarters of a million, and the amount expended for the removal of obstructions caused by snow and other miscellaneous purposes is a little over half a million dollars per year.

There are about 2,000 miles of road that have been constructed under the Bonding Act. These roads are mostly macadam highways; but there are 6,000 miles of crushed stone or macadam roads constructed by the towns in addition thereto, and also about 8,000 miles of road which have been surfaced with gravel by the towns with the aid of the state. There are a trifle over 300 miles which are being constructed at the present time, making a sum total in the neighborhood of 2,500 miles of state and county roads which will be completed during the year 1909. Add this to the 6,000 miles of stone roads built by the towns and the 8,000 miles of gravel roads, and we have to-day in the state of New York 16,500 miles of improved roads. It is safe to say that at least between 30,000 and 40,000 miles of road in addition thereto have been shaped and crowned or turnpiked, so to speak, so that within the bounds of the Empire State we have a system of improved roads involving between 50,000 and 60,000 miles of highway.

The farmers of New York state feel that too much money is being expended in the improvement of the highways for the kind of highways we are getting. There is too much red tape, too many incompetent men engaged as inspectors, etc., too much money expended in preliminary work, such as surveying, mapping, and office work, too little attention given to preparing the foundation and drainage. The question of drainage is perhaps the most important of all, for without proper and sufficient drainage no method of road construction can ever be made successful. Surface drainage will not suffice in making a permanent road in most sections. Tile or underdrainage must be the system, before permanency will be maintained. The larger number of our highways must still be dirt or gravel for ages to come, and a large proportion of these can be made almost as good as macadam, most of the year, by properly tiling them, and no money can be expended to greater advantage than in tiling. Surface drains soon fill with slush and snow and

refuse, which hold the water, permitting it to permeate the road bed, which softens it and allows the frost to penetrate. Even the macadam or Telford will not stand frost, but which by proper tiling will keep the roadbed dry and hard.

The highways of the country are of vastly more importance than the so-called waterways, which are receiving so much attention just now. The deep waterways, such as the Great Lake system and such rivers as are by nature deep and navigable, should be maintained; but transportation by water on canals and streams that have to be maintained by state and nation at enormous expense are antiquated and slow, and should be relegated to the past. The highways, railroads, and deep natural waterways should and must be maintained, and the whole people should help to do this. Perhaps in the near future we shall have the new and modern method of transportation to cope with, and laws will have to be enacted controlling the navigation by air through the great Milky Way.

The Grange, the great farmers' organization, stands for the improvement of the highways of this country through national aid, believing the national government can do no greater work toward the prosperity of this great country than that of improving the highways, thus aiding the greatest industry of the country in transporting to the markets the magnificent and bounteous products of nature at the lowest possible cost and yielding to the producer the profits entitled therefrom.

Mr. Godfrey, during the reading of his paper, interpolated several instructive remarks. For example, he said:

I was the first one to introduce the square-timber drag or scraper into our community, and we were ridiculed and laughed at, saying that it would do more damage than good, and from that square stick of timber came the road scraper, which is being used in our community very intelligently.

I have noticed in former addresses at this convention that very little has been said about tiling. All speak of drainage and good foundation; but they have neglected a very important point in not considering the subject of subdrainage or tile drainage more thoroughly. No good road can be maintained on level land—that is, land that is ordinarily level—by shallow surface drains through our section. The surface drain gets filled with snow and refuse during the winter time, and it fills with slush and water soaking in, instead of running off, and the soil underneath the macadam becomes permeated with moisture and wet, and away goes the road. Miles of road have been destroyed by neglecting to take care of the water; and, while they put their surface drains, this does not take care of the water in the winter time. A tile drain will properly take care of the water, so that no moisture goes under the macadam.

Any farmer who has done tile draining on his farm well knows the value of tile drainage, and I have often heard it stated by some: In laying tile drains, you should fill the drain with stone or some

loose material. Water will find its way to a tile drain through the hardest kind of blue clay for many feet. Two drains, 3 feet deep and 32 feet apart, in blue clay, will thoroughly drain that soil of surface water.

I lived alongside the Erie Railway, and up to a few years ago they were having trouble with their road in the spring of the year in consequence of the frost, etc. It follows along the side of the valley in a side hill, and although they had a good open drain they always had trouble till they tile-drained it. A few years ago they laid a tile drain for many miles along the upper side of the track, and since that time they have had no trouble in the spring of the year by the road getting out of shape, thus proving the value of tile drainage over surface drainage or gutters. A large number of our highways must be dirt or gravel for ages to come, and a large portion can be made almost as good as macadam by properly tiling them.

At the close of his paper, **Mr. Godfrey** said:

I might say a word in regard to some of the waterways that New York has had to contend with in the last few years. Ten years ago there was nine million dollars voted to improve the Erie Canal, running from Buffalo to Albany or Troy, entering the Hudson river at that point. There was very little improvement, apparently, from the expenditure of nine million dollars. About four years ago, maybe five, the people voted to expend $101,000,000 to enlarge the Erie Canal to a barge canal, and that is being expended; but it is the greatest fraud ever perpetrated on the people. Never in the history of this country will that canal be made valuable and profitable to the people. It is simply an expense to the state, without any recompense to the people therefrom. We do not need canals in this country. The many railroads that are crossing our country can transport our crops to much better advantage and cheaper than the people can afford to maintain a canal for that purpose. This canal across our state is for the purpose of transporting the products of the West to the seaboard. No tolls are charged for that purpose. It is a free waterway, and yet the people derive no benefit from it whatever.

GOVERNMENT AND OTHER AID IN ROAD BUILDING.

This was the subject allotted to **Mr. R. M. Brereton**, of Oregon, and in an exhaustive paper he did full justice to his subject. In commencing his paper, he said:

When the president of the Good Roads Association called on me a week or two ago to give you an address on Good Roads, I hesitated about doing so, because at my age—I am close on 80—I felt that younger men ought to take up this line of boosting good

roads; but my heart is in it. For 58 years I have been interested in the construction and maintenance of roads and railroads and irrigation works in both the Eastern and Western hemispheres of the earth, so that I can claim to have the authority of real practical experience, instead of mere theories, and what I want to say to you this afternoon, if it is possible for me to give you encouragement in the promoting of Good Roads throughout the country, I hope I shall be able to do so.

It has been my experience in my professional career in England, Scotland, India, and North America to come in contact with the farming communities to a large extent. With the millions of farmers in India, I have seen the burdens put upon them; with the million or more farmers in the United Kingdom, I have seen how they have borne the burden of the roads. I have seen it on this coast in California, Oregon, Washington, Idaho, Montana, Wyoming, and Nevada, where the pioneer farmers have constructed and been maintaining the roads for the benefit of the public. That has been a great injustice. I am not going to talk about the construction or maintenance of the roads. My professional brethren of a younger generation can talk about that. But I want to give you an old man's experience in regard to the financing of roads. I want to show you a better way for securing the money that is necessary to build good roads. You cannot get it out of the agricultural community. That is an injustice, for they have neither the ability, nor the time, nor the skill to furnish the money for the rapid transit traffic that is upon the roads at the present day. From my knowledge of sixty years I can tell you how much I have seen of the progress that has been made in all kinds of human life and progress. If you will permit me, I will give you a few instances.

A PROPOSITION FOR A NEW WAY OF FINANCING THE CONSTRUCTION AND MAINTENANCE OF ROADS.

By R. M. Brereton, M. Inst. C. E., Ex-Chief Resident Engineer of the Great Indian Peninsula Railway, Connecting Bombay with Calcutta and Madras, Ex-Chief Consulting Engineer for the Irrigation (1,200 miles) of the Entire San Joaquin Valley, California, Ex-Surveyor of Public Roads and Bridges of the County of Norfolk, England, Ex-Commissioner to the Late Duke of Sutherland; Having the Sole Charge of Those Estates; Special Pleader for the Establishment of Good Roads, and for the Utilization of the Natural Underground Waters, by Means of the Well System of Irrigation, in the Willamette and Other Valleys of Oregon.

Introductory.

My credentials in writing the following paper on the necessity for the nationalization, in the forms of finance and general administration of the Public Roads, are that I am nearly four score years

in physical age, and have actively followed the profession of a Civil Engineer during the past fifty-eight years in both the Eastern and Western Hemispheres.

During my life I have seen the marvelous progress made in national and international commerce and social intercourse through civilized human endeavor, skill, and scientific enlightenment, which evolution the engineers of a younger generation have not witnessed.

I have seen, and have been a participant in, the dawn and the zenith of the railroad arterial system of internal and transcontinental communications, in Europe, Asia, Africa, and North America.

I have seen the dark age of the primitive oil and gas lamps and tallow dip transformed into the light age of electric illuminations of city, town, and home.

I have seen the shilling rate of postage on letters reduced to the present penny and half-penny rate.

I have seen, and was employed on the construction of, the first largest ocean steamer, the Great Eastern, which laid the first Atlantic Cable of electrical communication between Britain and North America.

I have seen ocean communications between England and America reduced in average time from 20 days to five days.

I have seen the Thames and the Hudson rivers undermined by the construction of subways for car line and passenger service.

I have seen and observed the introduction and construction of both the cable and electric car lines of England, Europe, and America.

I have seen, and participated in, the irrigation of vast areas of arid and semi-arid lands in India and America, through which the food land has been greatly extended in area, and the population increased, and the welfare and well-being of both countries enhanced.

I have seen the utilization of both natural and artificial waterfalls for power purposes, the source of which is the annual rainfall, the everlasting "unearned increment" of the product of the sun's evaporation of oceanic waters, and of the aerial currents.

As a living witness of the incoming and outcome of all these wonderful transformations and utilizations of natural resources, through civilized human effort, skill, and intelligence, I feel, in my old age, fully assured that the present important problem of Good Roads, with the more rational, equitable, and economic financing and administration thereof, will shortly be solved in a manner satisfactory to the peoples of Great Britain and Ireland and of the United States.

During the past 58 years I have been an active participator in the construction and maintenance of public roads, and have seen and carefully studied the methods followed in Great Britain, Europe, India, and the United States of America.

For six years I had the general supervision of all the public highways of the county of Norfolk, containing about 5,000 miles of public roads, as well as the responsibility of carrying out the then new

"main road" system under the provisions of the Act of Parliament of 1878.

During this service in Norfolk, I also acted as auditor of all the public road expenditure in the county under the local government board, and thereby gained a close insight of the past and present system of administration, and of its weakness and injustice in the form of road finance, and which has been, and still is, the general system of the United States.

When Commissioner to the late Duke of Sutherland (whose estates in Scotland embraced over a million and a third acres and a population thereon of over 33,000), I was chairman of the commissioners of the public roads in the Highlands of Scotland.

For my six years' services on the roads and bridges of Norfolk I received a testimonial, signed by the county authority, the High Sheriff, the Lord Lieutenant, the present King of England, the principal landowners and rate payers, and the Bishop and clergy. One of the principal landowners was the Earl of Rosebery, ex-Prime Minister of England.

Norfolk is the chief agricultural county of England. It contains an area of about 1,291,000 acres, a population of 468,000, and $11,-971,295.

Norfolk has about 1,400 miles of main roads, or about 28 per cent. of its total mileage of public roads which have been established as "main highways" since 1878. The average annual cost of maintenance of these roads is $190 per mile, while the average cost of similar class of roads in England and Wales is $360 per mile in the rural districts.

Norfolk has about 2½ miles of all public roads to the square mile, and about three-fourths of a mile of main road to the square mile.

Norfolk has always had a high reputation for good roads. In the seventeenth century King Charles II. said: "Norfolk should be cut into slices as roads for the rest of the kingdom."

R. M. Brereton, M. Inst. C. E.

Woodstock, Oregon.

The Nationalization of the Public Roads System.

During the past one hundred years the Public Roads of Great Britain and those of the United States have been viewed by the people and their governments from a local rather than a national point, so that there has never been enough money and skill expended in their proper construction and annual maintenance.

The time is fully ripe for the English and American peoples and their governments to take a more comprehensive and national view of the extreme importance the public roads are to every form and degree of home, social, industrial, and commercial life. The unsatisfactory condition of even the main roads endured by the nation when the population was smaller, and when trade, industry, commerce, and all the products of agriculture, mine, and forest were infinitesimally small as compared with the present outcome, is no longer endurable.

Railroads, electric car lines, motor cars, telegraphs, telephones, wireless telegraphy, rural mail and parcel delivery, have all combined to quicken the pulse of national movement, and install impatience with delays in the mind of the present highly civilized public.

The majority of the American people form no longer, anywhere, slow-moving pioneer communities. They want to be in closer and quicker touch with their local and outside sources of social life and business.

The railroad artery of communication is rapidly enlarging in mileage and usefulness. Its sources of money for construction are not from any tax on the food lands of the nation, as are those of the public roads.

The essential vein system—the public roads—to the railroad artery does not respond to the needed social and business circulation.

Through the lack of this wholesome circulation, society, commerce, trade, and industry of every sort throughout the country are heavily handicapped with unnecessary cost and delay.

The railroad service especially suffers from periodic congestion, and from extra expense in the provision of rolling stock, which remains idle during months because of the bad condition of the public roads.

Over the whole of the Pacific Coast the railroad system is being projected into the rich wilds of plain and valley to enable more immigrants to come in and settle.

These have to make, at their own expense, such temporary roads as they can spare time and money for. The Government sells the public lands to these settlers; but not one cent from this revenue goes to the establishment of the public roads, as was foreseen and provided for by the framers of the Constitution. Furthermore, in reclaiming the arid and swamp lands of the public domain by irrigation and drainage for purposes of settlement, the Government gets back the entire cost thereof from the settlers, but provides no roads, as does the Government of India. The American farmer, in addition to the first cost of the land, pays the cost of reclamation, plus the cost of road construction, and plus the cost of annual maintenance.

Public Road Construction under the Constitution.

The fathers and framers of the Constitution, in section 8 thereof, displayed their foresight and wisdom in providing for the never-ceasing need of internal and interstate communications by Post Offices and Roads at the national expense throughout the area of the United States, as and when called for.

The language of this section is sufficiently explicit; it reads thus:

"The Congress shall have power to provide for the general welfare of the United States; to regulate commerce among the several States; to establish Post Offices and Post Roads."

The framers of this section of the Constitution well knew in their own day that public roads were essential to the welfare and

well-being of the nation, and that no national postal service could be established without the accompaniment of roads, and so they wrote "shall" instead of "may" have power to establish roads. To establish means nothing less than construction; but it does not include annual maintenance after construction. That part of it is local, not national, duty and policy.

This reading of the Constitution was established by Congress under the administration of President Monroe.

If the National Government fulfills faithfully this all important duty to the nation, as it does in the case of navigable waters and harbors, the local annual expenditure on the maintenance of the roads would be reduced fully one-half of the present; for the new roads on this coast would be built on sound and skillful principles to bear the growing public traffic upon them.

National Aid to Railroads.

The incompleteness of the national policy in its relation to local, state, interstate, and transcontinental communications is well illustrated in the partiality shown by the National Government to the railroad arterial portion thereof.

The arterial system is more or less valueless without the vein system. If the arterial system needed national assistance in cost of construction, a fortiori does the vein system need it. Why so? Because the railroad system has its pecuniary resources for construction from national and worldwide capital seeking investment; whereas, under existing policy and old-time custom, the construction of roads is purely a local duty, and a grievous and most unjust financial burden on the farming communities—that is, upon the food of the nation.

The mileage of public roads must necessarily far exceed that of the railroad system, and the first cost in construction, as a rapidly increasing population creates a greater mileage of roads, will approximate to, and may even exceed, the cost of the total railroad system throughout the Pacific Coast states.

During the past 40 years Congress has made a free grant of 266,000,000 acres, or 415,630 square miles, of the public domain to five transcontinental railroad systems, the total combined length of which is about 33,000 miles (8,060 acres per mile). This donation in area is equal to that of the whole of France and Germany, which contains a population of about one hundred millions.

The area donated to the Northern Pacific Railroad contains 47,000,000 acres, or 73,438 square miles. This is equal to the combined areas of the six following states: New York, New Jersey, Massachusetts, Connecticut, Rhode Island, and Delaware, which contain a population of sixteen million.

$532,000,000 would be a low valuation of these land grants to the railroads. This amount would suffice to construct one hundred thousand miles of first-class roads in the Middle West and Pacific Coast states.

When the fathers of the Constitution framed its section 8, the Railroad Age had not dawned; so that it could not have been in their minds when they provided for the construction of public roads.

There are now about 400,000,000 acres of the unappropriated and unreserved public domain in the West, and the future sale of one-half this area will produce a revenue of many millions for future road construction, if Congress would help the road system as it has helped the railroad system.

What is a service to all should be paid for by all the citizens, and public roads are an essential public service.

One hundred years ago the National Government constructed 700 miles of road, known as the "Cumberland Road" or "National Road," which cost $6,824,919, or $9,750 per mile. This practical experiment in cost of road construction shows the wisdom and foresight of the framers of the Constitution in viewing the road question from a national standpoint.

Use of Public Roads by the Postal Service Department.

No better illustration of the actual national service of the public roads can be given to Congress and to the general public than the daily use made of them by the Postal Service of the Government. In 1888 the Postal Department distributed seven billions of pieces of postal matter, or 110 pieces per unit of the population, through 57,000 post offices.

In 1907 it distributed over twelve billions of pieces, or 160 pieces per unit, through 63,000 post offices, scattered throughout the country. During this period of twenty years it has permanently established the Parcel Post and Money Order System in the rural districts, both of which are of an interstate and international character, and add largely to the immense tonnage of mail matter which must be moved over the public roads, and cause additional wear and tear to the surface thereof.

This National Department pays for its use of the railroad system; but it does not give a single cent for its daily use of the roads, bridges, and streets. Furthermore, it notifies its officers and the public as follows: "The establishment and maintenance of public roads is a matter wholly within the jurisdiction of state and local authorities, and a matter over which the P. O. D. has no control." From this it is apparent that the provision made in the Constitution for the establishment of Post Roads at the national expense is ignored or forgotten by the National Government, by the states, and by the general public.

The paramount agricultural interests, which furnish all the food and the great bulk of raw materials for the nation, are silent in the matter, and bear this unjust burden as best they can; so that it is no wonder that the public roads throughout the sparsely settled Middle West and Pacific Coast states are badly constructed and poorly maintained.

Railroad Traffic on the Public Roads.

The immensity of this traffic and tonnage over the public roads, and its interstate and international nature, is far too little recognized in the present demand for good roads at the expense of the agricultural communities.

Poor's Manual of Railroad Statistics furnishes a comprehensive idea of the immensity of the live and dead weight of humanity, and of its food and raw materials and supplies, and of its products of industry, which are conveyed and moved locally throughout the country yearly by the 220,000 miles of railroad which form the main arterial system of communication.

In 1907 the number of passengers carried was over one billion. Averaging these at 100 pounds per unit (including personal baggage) the aggregate live weight amounts to over fifty millions of tons. The dead freight weight moved amounted to about one and one-half billion tons.

Thus in one year this great arterial system distributed about two billions of tons of live and dead weight. It is reasonable to assume that the greater portion of this immense national traffic must have used the public roads, bridges, and streets throughout the rural and suburban districts of the United States, and caused most of the annual cost of their maintenance.

The present Pacific Railroad Group serves a series of states wherein population is comparatively sparse and scattered, and a vast area of land very little developed, but producing an immense tonnage of grain, hay, fruits, minerals, lumber, cattle, sheep, dairy and poultry supplies, and manufactures.

In this Group there are about 13,500 miles. In 1907 the number of passengers carried was forty millions; weight thereof two million tons. The freight moved was about twenty-eight million tons, making a total of thirty million tons.

Urgent Need for Road Improvement.

The foregoing statements, showing the present and the increasing use of the public roads, and the immensity of the moving tonnage thereon, show very clearly that these must be more strongly and skillfully constructed and maintained to enable them to meet the public demand throughout the year. As railroads are viewed as Permanent Ways, so must the public roads be. Both involve a large expenditure of money per mile in first cost of construction in order to reduce the cost of annual maintenance.

The policy of the railroad system in regard to the Permanent Way construction must be adopted for the public road system. Heavier steel rails and better drainage ballast is the policy of the railroad system. Well-drained foundations, good, tough, and dustless surface, is the policy for the public roads.

As the civil engineer has achieved this policy in railroad Perma-

nent Way, he can be relied upon to achieve the needed policy for the public roads; for nature has provided the necessary materials, and only money and skill is needed to use them properly.

Cost of Present Haulage on Public Roads.

The public and the farming communities are still woefully ignorant about the enormous annual cost of haulage on bad roads. Owing to the general bad condition of the roads in the West, during one-half, at least, of the year, the average cost of haulage by animal power is about 25 cents per ton per mile. For the same cost railroads haul freight 50 miles; steamers on the Great Lakes, 200 miles; electric car lines, 5 miles.

Congress in March, 1893, appointed General Roy Stone to gather data, and to report thereon, of the cost of building roads and the cost of hauling freight over them.

General Stone's report to Congress shows the average cost of haulage per ton per mile as follows:

In the Eastern States	32	cents.
" Northern States	27	"
" Middle Southern States	31	"
" Southern (Cotton) States	25	"
" Prairie States	22	"
" Pacific Coast States	22	"

The average of these is 26.6 cents; average distance, 8 miles.

The Ohio Road Commission also reported in 1893 that the average cost of animal haulage on the roads was 25 cents per ton per mile. General Stone's estimate was based on the total tonnage moved by animal power on the roads of the United States in 1892, which amounted to 500,000,000 tons over an average distance of 8 miles. This estimate shows that the cost of haulage on the roads for one year amounted to $1,000,000,000.

If the roads had been constructed and maintained on scientific principles, as the railroads are, the cost of haulage would not average over 12.5 cents per ton per mile, and would save the owners of animal power $500,000,000 a year. In France the average cost of animal haulage on good roads is about 10 cents per ton per mile.

This annual excessive loss in wear and tear of wagons and harness, in damage to horses from overstrain, in time through slow travel of freight over bad roads during many months of the year, is clearly disclosed in the following letter from Mr. Stuyvesant Fish, President of the Illinois Central Railroad, to Governor Lowry, of Mississippi. In this he refers to General Stone's report to Congress in 1896.

"Circular 19, Office of Road Inquiries, bears date April 4, 1896, and the annual cost of hauling farm products and lumber on public roads in the United States, therein given as $946,414,665, is based on data for the year ended June 30, 1895.

"In that year the gross sum received by all the railroads in the United States, for not only hauling all freights, but for also providing in addition the railroads, the cars, the engines, and the trainmen, and paying taxes thereon,

was only $729.993,462; that is to say, it cost the farmers and the lumbermen of the United States alone $216,421,203, or 30 per cent. more, in one year to haul their products on public roads than all the railroads received for freights of all kinds. Moreover, 70 per cent. of the gross receipts of the railroads are spent in taxes, labor, and materials, while bad roads return nothing."

Cost of Good Roads.

The general public, who are now clamoring for good roads, have little conception of the cost per mile of proper road construction. The following data affords a fair illustration of this cost in the following countries:

Great Britain..........................$4,000 to $6,000, width 20 to 30 feet.
France ....$6,000 to $7,500, width 25 to 50 feet.
Italy ....$3,000 to $4,000, width 18 to 25 feet.
New England States.................$7,000 to $9,000, width 30 to 60 feet.
United States..................average, $5,415, 13½ feet metalled macadam.

Great Britain and Ireland contain 228,438 miles of public roads. The present annual cost of maintenance of these amounts to $79,-453,240, or $348 (nearly) per mile. The average cost of the principal main roads, on which there is heavy traffic, is about $1,650 per mile. These form about 37,000 miles, or 16 per cent. of the total mileage of all roads, the total of which shows about 2½ miles to the square mile of country.

In the United States in 1904 there were 2,151,570 miles of public roads. The total expenditure on these for that year (1904) amounted to $79,771,418, or $37 only per mile.

Of this gross mileage, 155,662 miles, or 7¼ per cent. only, were improved surface roads.

The average cost of construction of good roads during recent years has been as follows:

Pacific Coast States..............$7,707 per mile, or 84 cents per square yard.
Middle West States...............$5,123 per mile, or 66 cents per square yard.
Northern States..................$5,750 per mile, or 75 cents per square yard.
Southern States..................$3,082 per mile, or 42 cents per square yard.

This shows an average first cost of $5,415 per mile of road, and about 67 cents per square yard of hard surface, averaging in width 13½ feet.

Ratio of Roads to Area of Country and Population.

There are 37,000 miles of main roads, or about 16 per cent. of the gross mileage, in Great Britain and Ireland. This represents about 0.42 miles of main road to the square mile of settled and cultivated land, and about one mile to every 1,100 inhabitants. The United States of America has an area of 2,970,038 square miles, exclusive of Alaska and Islands. Its 2,151,570 miles of all roads represents about 0.78 miles of road to each square mile, and .027 miles to each unit of population.

The annual expenditure on all roads in Great Britain and Ireland approximated with that of the United States, being nearly $80,000,-

000. Taking the population of the former at 42,000,000 and of the latter at 80,000,000, this annual cost represents $1.90 per unit of the population for the former and $1 for the latter.

The total annual maintenance of the 37,000 miles of main roads in Great Britain and Ireland is about $6,305,240, or about 8 per cent. of the total annual expenditure on all roads.

New York state, containing an area of 49,000 square miles, has provided a bond issue for its public roads amounting to $50,000,000. Massachusetts, with an area of about 8,000 square miles, has about 2,200 miles of main road, which have cost the state nearly $20,000,000. Pennsylvania, containing 45,000 square miles, has appropriated $6,000,000 for the construction and improvement of public roads.

Indiana, containing 36,000 square miles, has established the largest mileage of hard surface roads of any state in the Union—about 25,000 miles. Thirty-five per cent. of the main roads have been constructed and improved, from time to time, through the issue of bonds at the rate of $2,000,000 per year.

Michigan, containing an area of 59,000 square miles, pays a bonus of $1,000 per mile for the construction of macadamized road.

Connecticut, containing an area of 5,000 square miles, pays two-thirds of the cost of good roads, which varies from $7,000 to $9,000 per mile.

Mileage Ratio of Roads to Railroads.

As the total annual expenditure on public roads in Great Britain and Ireland is nearly the same as it is in the United States, so also is the mileage ratio of all public roads to railroad mileage the same.

	Railroad Miles.	Road Miles.	Ratio.
Great Britain and Ireland	23,108	228,438	9.88
United States of America	227,671	2,151,570	9.45

The amount of capital invested in English railroads is about $6,500,000,000, or $280,000 per mile; that of the United States is about $16,500,000,000, or $72,500 per mile. This amount would suffice to construct 12 miles of good road, at the rate of $6,000 per mile, to every mile of railroad in the country. That is probably what the mileage ratio of roads to railroads will be when this Pacific Coast becomes as populous as the Atlantic Coast.

Injustice of Present Financial Road System.

The long past and still existing system of financing the cost of public road construction is of a barbarian and feudal origin, inequitable, inadequate, and unbearable in this twentieth century. The present road tax on realty in the rural districts of the country, and the public duty in road construction and efficient annual maintenance, fall as a grievous burden upon the shoulders of only one of the industrial classes of the nation, and that one which alone supplies the food of all.

It is fast becoming a very serious matter to the farming communities of the largest states in the Union—Texas, California, Oregon, and Washington—who are now being called to satisfy the rapidly growing demand for good roads, which shall be kept good and serviceable for motor cars throughout the year.

As the railroad system came to stay, so will the motor car system stay with us; and so will the National Postal Service continue to expand and use the roads. This national and internationl use of the public roads is pregnant with forcible argument for the nationalization of the public roads.

In 1901, 511,808 miles of the public roads were used by the Postal Department. As the railroad system has been extended in the West during the past decade, it has reduced somewhat the length of the Postal Routes. The average mileage used annually during the decade ending 1908 is 481,000 miles. This is nearly one-fourth of all the road mileage of the country.

During the same decade the National Government has paid the railroad corporations and stage owners for the transportation of the mail $674,363,597, or an average of $67,436,360 a year. Not one cent of this expenditure helped to construct or maintain the roads used by the stages and carriers of the mails.

Motor Car Traffic on Roads.

Nothing has ever before shown so much to the general public the importance of good roads throughout the country as has the advent of motor vehicles of all kinds. In Great Britain and in the United States this advent has created a widespread demand for well-surfaced and strongly built roads; for the use of these vehicles has increased the wear and tear of the surface, as well as the terrible dust nuisance.

The following table shows the increase in number of these vehicles on some of the main roads in England, between 1904 and 1907, and the increase in cost of maintenance due to them:

Year.	No. of Motors.	Miles of Roads.	Total Cost.	Rate per Mile.
1904	51,549	27,223	$11,830,815	$435
1905	74,058	27,367	12,033,770	440
1906	86,536	27,580	12,392,405	455
1907	125.320	27,556	12,645,685	460

Previous to the use of the roads by motor vehicles, the average rate cost per mile was $380; in the year 1907 this rate had been increased $80, or about 21 per cent.

It is estimated that to improve 4,500 miles of main road in England, which are now maintained with flints, gravel, and limestone, with basalt and granite materials and tar, will cost about $5,500 per mile, or a total expenditure of $25,000,000.

In the United States the number of motor cycles in use is about 50,000. The number of automobiles is about 200,000. It is esti-

mated that over 50,000 of these latter vehicles are being manufactured yearly in the United States. Those produced in 1908 amounted in value to $122,000,000.

Besides the above numbers of motor vehicles in use on the roads, about 5,000 steam and electric vehicles are being yearly produced.

This vast increase of rapid-moving and heavy traffic on the roads calls for national aid in the construction of the roads, as provided for in the Constitution, and state aid in the yearly maintenance of them.

It is simply idle and absurd to call upon the farming communities to meet this new and ever-increasing demand for better roads. They have neither the financial ability nor the time and skill required to do it.

The food lands of the nation should not be wholly taxed, as they now are, for the construction and maintenance of the most important vein system of internal communications.

After a century and more of national lethargy and gross injustice to the agricultural community, public opinion in Great Britain has sought a new way with this public road question; so that the Chancellor of the Exchequer in his recent Budget has been enabled to make a new and most important advance towards the improvement and maintenance of all main roads in the kingdom. His proposition is to tax all motor vehicles and the petrol used in them. This tax is estimated to yield in 1909–10 the sum of $3,750,000 from the United Kingdom and Ireland. It forms the first national financial aid to the public road system.

The railway passenger duty, amounting to about $1,750,000 a year, should also be devoted to the maintenance of the main roads, because this traffic is more or less contributory to the wear and tear of the roads.

This new national road policy in England could be easily adopted in the United States, if the mind of the general public were awakened to its urgent necessity, and if the agricultural and motor car interests would combine to move Congress out of its too long endured inertia in the matter of public roads.

The existence of 200,000 motor vehicles on the roads at the present time, calling for an additional expenditure of several thousand dollars per mile in the use of better surface materials, and requiring more skill and experience in construction than the present system and its authorities can furnish, form a very strong appeal for help to the National Government.

The capital already invested in motor vehicles is now so large—probably $250,000,000—that the roads should be made serviceable for them, and reduce the cost of their repairs.

The first transcontinental railroad corporations, with less capital invested at the start, were able to obtain a large amount of financial help from Congress, in the form of land grants and in guaranteed interest on their first bonds, for the construction of the arterial system of state and interstate communication.

The promoters of good roads throughout the country should not be discouraged in their efforts to move the National Government

into the new way of viewing the public roads as the vein system of internal communication, and in forwarding it under the existing power of the Constitution.

National Ways and Means.

No civilized country on earth is better able to afford the cost of good roads, and to need them more, than the United States. The United States produces 63 per cent. of the world's production of petroleum. Gasoline is one of the refined products. Without the use of it, the present motor car system would not be what it is to-day. Petroleum in every form is now in use by all classes.

Statistics for the fiscal year ending June 30, 1908, show that over 135,000,000 gallons of crude oil and over 26,000,000 gallons of refined oils were exported, amounting in value to about $104,000,000.

Why not put a duty on these exports, and therefrom secure a yearly revenue for road improvement?

A royalty on the artificial use of the "unearned increment" of natural waterfalls, and a reasonable tax on all artificial water power used for industrial purposes, would be a fair proposition for the relief of the existing heavy road burden on the cultivators of the food lands of the nation; for it should be well borne in mind that a very large percentage of the raw products used in the manufactories throughout the country come from the farming industry of the nation.

Furthermore, the water used for power purposes is the "unearned increment" of the natural rainfall.

A reasonable duty on all lumber exported is also a fair proposition for the benefit of the roads, because the natural forest also forms one of the national "unearned increments."

Raw products from field, forest, and mine are transported over the roads, and create their percentage of the annual wear and tear thereof, and so should contribute to the cost of maintenance. All of these raw products pay freight rates to the railroad arterial system of transportation; therefore these should also contribute to the public road vein system.

Economy in Road Width.

The citizens of the Pacific Coast have been too prodigal with their right of way for public roads. The present average is a width of 60 feet, which represents an area of 7.27 acres per mile of road. In Great Britain and Europe one-half of this width, or 3.64 acres per mile, is considered ample for thickly populated rural districts.

The Pacific Coast states are sure to become densely populated. Land that can, in the future, be utilized for the production of food should not be wasted. Lands cannot increase in area; but population will continue to increase.

California, Oregon, and Washington form the "Ultima Thule" of the western portion of the United States. There can be no Farther West than their ocean boundary for immigrants to settle on.

The Secretary of Agriculture in his last report gives the average

width of right of way obtained for all roads as 40 feet, or 4.85 acres per mile of road. The aggregate acreage valuation of the entire road mileage of the country is about 350,000,000. This shows a value of $163 per mile of road, or $33.60 per acre of right of way.

A reduction of 20 feet, or one-third, in width of roadway on this coast, at the above valuation, would, in the future demand for cultivated land, effect a saving to the farming community of 2.42 acres, of the value of $81.27, on each mile of road. Massachusetts has 4 miles of main road to the square mile. If in the future, under the extension of the irrigation system, California, Oregon, and Washington become as populous as Massachusetts, they will each require an approximate mileage of roads. Deducting the area of the Sierra Nevada and Cascade Mountains, it is probable that California will require 30,000 miles of road, Oregon, 20,000, Washington, 15,000—making a total for this coast of 65,000 miles.

By making the right of way to average 40 feet in width, instead of 60 feet, there would be a saving in land of about 157,000 acres, amounting in value to about $5,275,200. The value of this "unearned increment" would suffice to construct over 1,000 miles of road.

Wealth of the Nation.

The true wealth of the country is in the industry of the people. The inherent wealth, in the natural resources, or unearned increments, of soil, forest, and mine, is worthless without the toil and skill of humanity.

The Secretary of Agriculture in his last report to Congress estimates the total value of all farm products from the soil at about $7,750,000,000. Ten per cent. of this was exported to feed the people of foreign countries and to furnish raw materials for their manufacturing industries.

In 1907 the value of the products of the field exported amounted to $1,000,000,000. The estimated weight of the farm and forest products moved over the public roads is 25,000,000 tons a year.

At 25 cents per ton per mile, the haulage of this tonnage over the roads cost the farmers and lumbermen $6,250,000 a year. The estimated present number of farms in the United States is 6,100,000, and their value $28,000,000,000.

The adult population of this national industry is about 10,500,000, or about 13 per cent. of the entire population.

The estimated annual cost of all roads is about $80,000,000. This cost now falls mainly upon the agricultural industry.

The entire wealth of the United States is estimated to be $116,000,000,000; the value of the annual agricultural products is about 6¾ per cent. of the national wealth; the annual cost of the roads is about three-fourths of 1 per cent. of the national wealth.

With the evidence that these national statistics afford, the agricultural community may well ask why it should alone continue to bear the financial burden and duty of this national service, the annual cost of which amounts to 1 per cent. of the total annual value of the products of its industry.

History shows that for thousands of years the farming communities of the world have been the most imposed upon with these national services. The Hebrew farmer Issachar was described by his father, Jacob, "as a strong ass, crouching down between two burdens, who saw that [farm] rest was good, and the land was pleasant, and he bowed his shoulder to bear, and became a servant under tribute."

The world has seen how well this patriarchic prediction has been fulfilled. Priestcraft enacted the tithe system, levied on the products of the food industry; kingcraft levied ruthlessly upon the shoulder labor and products of the farmer.

The Pyramids of Egypt stand forth as a lasting memorial of the enforced labor of the Fellahin farming community; the Great Wall of China—1,500 miles in length—was built by the forced labor of the tillers of the soil; the numerous splendid Hindoo and Mohammedan temples and temple caves of India are the outcome of the forced labor of the Hindoo ryot farmer; the grand roads of the Roman Empire were the outcome of the forced rural labor; the public roads of Great Britain have been constructed and annually maintained by the owners and tenants of the food lands of the nation under the unwritten law of "prescription," dating back to the time of King Richard I—a period of 800 years—and supplemented by Royal Acts of Henry VIII and of William IV; the public roads of the United States are the products of the agricultural labor and money through old established custom, and neglect of the road provision in the Constitution.

Time for a New Way.

The great railroad arterial system of internal communication, with its invested capital of nearly $11,000,000,000, the motor car enterprise and industry, with its invested capital of $250,000,000, and the agricultural industry, with its invested capital of $28,000,000,000, representing an invested present total capital of $39,250,000,000, or 33½ per cent. of the total wealth of the nation, should now combine to secure from the National and State Governments an entirely new system of financing, constructing, and maintaining the public roads of the nation.

This paper has only touched upon a matter of the very highest importance to the nation, one which ought to occupy the careful attention of all thoughtful citizens, because on the equity of the mode of raising money for this national service the service itself depends, and because the economic use of the money raised demands skill and experience which the existing road administration cannot possibly exercise.

It is the work of the statesmen in Congress and in the state Legislatures to carry out this new national policy in regard to roads to a satisfactory and noble end.

[Signed] R. M. Brereton, M. Inst. C. E.

Woodstock, Oregon, July 1, 1909.

SOME FEATURES OF MACADAM CONSTRUCTION.

"Some Features of Macadam Construction" was the subject of the address of **Mr. A. N. Johnson**, of Illinois. He said:

I hope to go into details of what I may eventually prepare as a paper for this Congress. There are two or three points in connection with macadam construction that I will touch upon, assuming that most of you are road builders or immediately connected with the work. We have already had touched upon the preparation of our road as to matters of drainage; but if you are a road builder, and were perhaps following out the advice given, which was good, you might think that it is absolutely necessary to underdrain every mile of road you would undertake. I have known many miles of road underdrained and money wasted because it was not needed. It is as good engineering to let go what is unnecessary as to put in something as a sort of hazard or guess. Only in accordance with judgment based on experience can we do those things, and what would at first appear like taking a chance is taking advantage of what experience we have had to let go useless work. It is a simple matter in one way, with enough money to go ahead and make almost anything that will stand. The point is: Should we put more money than is absolutely necessary to make it stand? The difference between that construction in the one case, putting in an immense amount of material and putting in only what is necessary to get a good thing, is the difference between engineering as I regard it and mere constructive talent.

The question of underdraining a piece of road depends upon the conditions, and, knowing these, it is not a very difficult matter to decide whether underdrainage is necessary or not; and I would advise, assuming I could have charge of a certain system of roads for a long enough period, I would advise leaving out the underdrainage where I was in doubt, rather than put in useless underdrainage.

As a matter of fact, in most of the work that I have had to do as city engineer and as engaged in government work, in most of the work that Mr. Campbell has had to do in Ontario, and other city engineers have had to do, the trouble has been that we were not in a position to make any such experiment. We have to make a piece of road that will stand anyway, simply because we are making a piece of road. It is an object lesson. Because we have to construct that object lesson road, we are sometimes driven to put in a form of construction that in our own judgment we are almost sure is unnecessary, and would be probably unnecessary, if we could have a system of roads directly under our charge for a certain number of years, so that oftentimes the work done by city engineers is necessarily expensive, possibly more expensive than it would be, for instance, if you were engineer in a county, and had a defined unit to work in, and to work out your own salvation for a given number of years; and I would not be so much concerned under those con-

ditions with the first construction, whether I used the best construction or not, provided I had long enough to maintain and keep them up. We select a material, add a little, perhaps, and eventually we get the roads. We put in only the material that the demand requires, and eventually we get a system of roads absolutely the cheapest, so that it is pretty hard to lay down definite rules or specifications that can be followed, even in what might look like similar physical conditions.

I find, in the matter of underdrainage, a pretty safe guide in most cases, if you want to be sure that underground water is present, if the ground shows trembling or shaking, especially a few feet beyond where the wagon or the horse may be, that there is underground water, and you would have to use an underground drain to get rid of it. In level roads, the fact that the road is muddy for a long time, and the water stands in pools and alongside the road, is not necessarily evidence that the underdrainage is defective. It simply means in most cases that we have a retentive soil, with imperfect surface drainage; that if the surface drainage were properly divided, flowing to one side and longitudinally along the road, there would be no mud.

So you see it is hard to say that drainage indifferently applied is necessarily a good thing. We can have too much of it; that is, if we have to pay for it. The point is, and which was intended to be conveyed in every instance where it was mentioned by the speakers here that I have heard, the point is that a road to be perfect, has got to have drainage, that may be partially provided by the natural condition of the soil, where there is no need of underdrainage because there is no water to be taken away, and when we have a road in that condition we will have a foundation provided that will hold up the surface.

In explaining round our Farmers' Institutes as to the principles of making a road, I have said there was one main principle, which was that we shall have a water-tight roof to the road. If you would take one of our muddy roads and lay on it a piece of canvas, you would have no mud underneath, provided that it remained tight and in shape that the water would flow off, and you did not get water coming in underneath, and if that canvas would resist traffic you would have a mudless road. Whatever we do, we will eventually have to put on a water-tight cover. Macadam and gravel becomes water-tight, and any successful road surface must be so, or else we have a leaky roof, and the water gets into the foundation, and it has no bearing power.

There have been some experiments made on rather a small scale to show the bearing power of a compact mass of material, grains of sand and pieces of stone forming a macadam or gravel road. They have not been conducted far enough to show to what extent that bearing power is affected; but it shows that it is a great deal more than we have been led to suppose. We have assumed with a road 6 inches thick that it had a certain bearing power, and 8 inches was increased in proportion; but as a matter of fact these experiments seem to show that it increases very much more rapidly,

the rate being possibly the cube of the depth, so that the difference between 6 and 8 inches in bearing power is a great deal more than the relative thickness would indicate. I hope, if the scheme works out, to make some experiments which will in a measure demonstrate this in a measurable way to get some more definite information on that point.

In the work I have come in contact with, I have come to the conclusion, if an 8-inch road does not hold up under the traffic, the trouble is not with the material necessarily, or that the thickness—that is, adding material—would help matters very much. We have got a foundation that is poor. I don't believe there are very many conditions where we are called upon to build a road that needs more than 8 inches of well-compacted material. If we need more than that, or put in more, it simply means, probably, we are raising our wet foundation until we get a sufficient thickness of dry material which will support our traffic.

In picking out the material that is to be used, we know that there are different properties possessed by different rocks, and that we had explained to us very clearly this morning. The difficulty, however, practically arises from the fact that we have in most instances little choice. Our choice is not so much between good and bad, and possibly better, materials; but we are practically compelled to use what we have on hand, for a 4-mile increase in haulage will almost double, or add 50 to 100 per cent. to, the cost of our road. The problem seems to me to be, if we have a poor material, to use the method in applying that material that will get the most out of it.

Again, we cannot say off-hand what is the best material; in other words, there is no best material for all conditions, from the fact that a road depends for its conditions largely upon climatic conditions, as to whether it is exposed to wind or rain, on the amount and kind of traffic that goes over it, and a material that will give you excellent results under one condition, under other conditions will prove a failure. One road in particular I have in mind. They used the best kind of trap rock, and trap rock we know is extremely hard, very tough, and satisfied most of our laboratory conditions; but that rock did not satisfy the traffic conditions, for this reason: That although it was a very hard and tough rock, and would wear a very long time, it wore off but very little. This particular piece of road was exposed to wind and to a very small amount of traffic, and the result was that the traffic was not sufficient to wear off very much of that material. It was not heavy enough to keep it pounded down, and what did wear off was blown away. That same road, if they had put heavy wagons over it and enough, would have been a success. A softer material was used, a limestone that in the laboratory would not show as good results; but it was better adapted for those conditions, and was a success. It had a better binding power and was softer; it wore off a little faster, and remained cemented together; and we had a condition where it proved that a good softer material was the better material. So, as I said in beginning, we cannot off-hand say any one rock is best. If we

have a material that we have got to use, and we know, from the laboratory examination of it, it is not suitable for the traffic we have to provide for, the question is: Can we use it to better advantage in one way than another? Now, in the conditions I have to meet in Illinois, I have practically one material, and that is limestone, but not a great deal of difference. For instance, where an extra good material is required, assuming the traffic conditions require a hard material that would be graded as 20, this limestone would grade 8 and 9; so it is rather a poor material. The problem I have to solve is to make the best I can out of poor material, and it is a problem many of you have presented to you. We have found, and it has been proved time and again, that with a traffic on an ordinary country road as we find it, with 100 to 150 vehicles a day for every day in the year, it requires a fairly good material; but with this softer material we have, if we should put on and build the road in the ordinary fashion, with the 1½-inch size for the top surface, and then put the 3-inch size in the foundation, we would have a road that would get smooth very shortly after it was built. It would look pretty well, and then begin to look worse and worse. It would grind up, and the 1½-inch pieces of the rather soft material prove too weak to hold up the traffic, and it generally breaks up; whereas, with 3-inch pieces of the material, the road does not break so easily, and the wagon wheel does not crush it all to pieces, as with the smaller pieces. In other words, the surface of the road, when composed of the 3-inch pieces will wear from five to six times as long as when composed of pieces about half the size. If that is the case, and we have the softer material, use the larger pieces on top, and by so doing get about four or five times as much out of the material as you would get following the usual method of construction of putting the medium size pieces on top.

There is another feature which you will find of great help and assistance in rolling roads and getting them compact. Many of you have noticed, in using some materials, that the more you roll it the more trouble you seem to have. The stone would get a wavy motion and it seems almost impossible to get the stone to come together. One thing that will do it quicker than anything else is to thoroughly harrow the stone before you attempt to roll it, and you will be surprised to see how quickly that material will come together and how compact it will become, and the explanation is simple. You take a layer of different sized material, and crushed stone has different sizes in the single layer, from the smallest piece that has gone through the screen up to the largest that can get through, so that a layer of crushed stone is not of the same sized pieces. If we harrow that material, and stir it up, the largest sizes will come to the top. You know that, and the grocer knows it when he displays his apples and fruits. All he has to do is to shake the basket. When you want to get the even sizes of the stone on top, shake it up, and you can do that with a good strong harrow; not a farmer's harrow, but you would have to have one with good strong teeth, the frame weighing perhaps 400 or 500 pounds. Have a man ride it, and a team can draw it easily. That stone is shaken

up, and the largest sized pieces come to the top, and it all shakes down, and you will find that there is no other position in which you can put that material and have it denser or more compact; for, after you have once broken up the stone, you cannot get it back the way it was. You can never get it back, and if you attempt to let a road go without raking it over you have the large pieces of stone, and then the small pieces, and then larger pieces, and then a space, and you want to drop the smaller pieces, so that the two larger pieces can come together, and you do that when you harrow the road, and the smaller pieces will get down, and if anything disturbs the road the smaller pieces will never come to the top. You have a more stable road than when you put on your roller and you find the material will wave and creep. We all know that even sized pieces in the surface of roads get better results, and the harrowing brings the pieces of the same size to the top, and so we get what Macadam laid down—that pieces should be as uniform in size as possible.

The quality of the road material that we have investigated in this country, and which was mentioned this morning, and its binding power, I think a word could be said about that. In the first place, the tests on road material were devised and used primarily by the French engineers, and in 1878 they brought out a test that was designed to show the relative value of the materials to wear, and that test was very successfully developed, and we are using it to-day. But one thing they did not attempt to measure or test. They appreciated the fact that stone had a binding quality, but apparently they did not undertake to develop any way of testing that, and that has been a test brought out by engineers in this country, and I think it is as important a quality of a rock for road purposes as its hardness or toughness, because, as I said, in some conditions, where you have light traffic, to get a road to bind together is as necessary as to have it hard, and no matter how hard the material, if it has not binding power, you will have a failure. So the cementing value is a most important quality of road material.

You have undertaken in this state work that I think you will not regret, and which I think other states will follow, and that is the employment of convicts in preparing the road material. In Illinois we have had some experience in that, and I think perhaps a word as to the success of that plan as we find it there may be of some interest. We have two state prisons in Illinois, unfortunately, and we have erected a crusher plant at each place. It happens where the prisons are situated there is limestone rock in considerable abundance. These quarries have now been operated for about three years. The stone is distributed by the requisitions of the State Highway Commission, and we give it to the township, which is the local community carrying on the road work, free of any cost except that of transportation. They must pay the freight. They must also use this material in accordance with the directions that we give. We do not give the same directions in every instance, for the simple reason that in some places they have never done anything, and if they get the material on the road and make a

reasonable showing, that is a great advance in that community. In other communities they use some local stone, and the thing is to have them use it and get better results than ever before. In other cases we make an experimental road, and furnish machinery *and men* to take charge of the work. This has proved a very successful plan, and there in Illinois I do not know how we would have got on without the assistance of this material in making the roads we have been able to make so far. We went after the railroads, and got from them fairly good rates. The law permitted the Highway Commission to make a special arrangement for freight rates with the railroads, and I undertook to see the various railroad managers, presidents, or whoever I could see of the forty roads that are in the state, and I found that they lent a very willing ear to the proposition, and gave a very considerable reduction from the ordinary rates, and we have in effect a half cent rate throughout the entire state.

There are in Illinois some very extensive stone industries, and there was some opposition at first from them; but as they considered the matter a little more closely their opposition died down. There is opposition in Illinois to the useful employment of prisoners on the part of the labor people, from the fact that they claim that whatever they make which is put in the open market against free labor is an injustice to free labor.

In this employment of convicts in crushing stone, it does not interfere in most sections of the country with the existing industries. Take it in Washington or Illinois, the material that is going to be produced and is produced by these convicts goes to places where they did not buy any before, and therefore could not interfere with any existing industry. We cannot interfere with free labor, because we are interfering with no industry; but it makes more work for free labor on the roads. The way it works out in Illinois, it simply affects the prisoners in the prison. There is no increase to the taxpayers, because the prisoners had to be fed and clothed and housed, so that whatever they produced in the way of crushed stone was not produced at practically any increased cost to the taxpayers. I do not see how it is possible to work out a more equitable plan of co-operation on the part of the state than to put the convicts to work in the stockades and quarries, and it is more humane for the convicts, because it keeps them outside, and our experience has been that those men working outside are in far better condition mentally and physically, and discipline is maintained much more readily and easily, than where men are kept confined inside and in more or less unhealthy and unsanitary conditions.

I will add a word as to the use of convict labor. We made use of them in a bridge test we are carrying on now. We have a great many streams in Illinois crossed by roads, a great many bridges, and our bridge expenditure has been more than our road expenditure, so the question of bridges is a very important one, and we have taken it up rather expensively. We built the South Illinois Penitentiary, and have a concrete bridge with an 18-foot roadway

girder type; the floor hung up into the girders. The convicts built the bridge. That experiment was done with the ordinary labor conditions outside, and, where it would have cost us from $6,000 to $7,000, the cost of the experiment to the state, using convict labor, I do not think will be over $800. I don't think there is any better use that can be made of convict labor than the carrying on of some of these investigations that without this system seems to make the price prohibitive. I believe this experiment is perhaps one of the first instances of the employment of convict labor in scientific investigations.

DISCUSSION.

Mr. M. O. Eldredge: There are a good many sections in Oregon and Washington where they have trap rock and other forms of igneous rock, tough and hard. Did your remarks apply only in the cases of the softer rock?

Mr. Johnson: Yes; the ordinary traffic conditions as you find them on the country roads. If you have a very hard, igneous rock, do not attempt to put the 2½ or 3 inch stone on top; but, when you put in a layer of rock, harrow it. It will save rolling. Then put your next layer of rock, which may be 1½-inch. Harrow that, so as to save the road. If you attempt to use that material for a city street, then I have seen trap rock of the very hardest kind used in the 3-inch size, where there is enough traffic to hold it down.

Mr. R. H. Thomson: I come from a limestone country, and we used to have good roads in Southern Indiana. I am very much interested in this discussion concerning limestone, and this difficulty which you had with the small stone, and I was wondering whether that was not the same difficulty that first came out here in this country when the crusher was used—that in crushing the stone there was an excess of fine material. If you had left a lot of the fine stuff at the quarry, and not tried to use everything that came out of the crusher, would you not have had a better road for less money than trying to cart all the material on the road?

Mr. Johnson: I would say in this connection that in the large crushers we find that the proportion of dust made is not much in excess of what is absolutely required for binding purposes. It depends a little upon what layer of material happens to be in. We have here a few of our reports, which give in some detail the use of

convict labor and describe the work there. If any of you want them, I shall be glad to let you have them.

Mr. Lancaster: There is one point that does not seem to have been brought out very clearly, and which I think may be worth mentioning, and that is the soil conditions in Illinois. The soil is a very black, sticky character in most cases, and I think Mr. Johnson will agree with me that, where the smaller material was used, it was inclined to get out of the road. When the wagon came on the road, and went over the black mud, it was inclined to kick out badly, and the use of large stones was in order to prevent the material kicking out so badly.

Mr. Johnson: In roads that are used for automobile traffic, sometimes, where you find a little nest or nests, and oftentimes, one will slap on some screenage, go away, and it looks fine; and again, oftentimes, the way the stones will come from the crusher once in a while, the small pieces seem to get together, and if it is not carefully harrowed the automobile traffic will always detect those places where there is a nest of small material. So if you can harrow your stone, and get it more evenly distributed, it will wear very much more satisfactorily, and won't tear up near as much with the large pieces of stone as with the smaller pieces. With any severe amount of traffic, you cannot maintain a macadam road anyway, and have to put something with it.

Mr. Lancaster: Have you used oil or coal tar?

Mr. Johnson: Yes; last year we used some oil and coal tar on two or three miles. I do not know if it is going to prove the best that could be used. The chemists are not altogether decided as to what we ought to use, and after we have gotten material I don't know if the engineers have made up their minds as to the method we should use—whether we should mix the material beforehand and lay it in the road, or whether the road should be laid and the material put in, or whether we should use another method and force the material in putting the tar into a tank with air pressure and squirting it into the road. If there is any considerable traffic, we will have to do something with it. It is no use talking about macadam roads and maintaining them, if we are going to have much motor traffic over them.

Mr. Morrison: I can see how the larger pieces of rock on the surface of the road would give greater wear; but in my experience, wherever the larger sizes of No. 1 have come to the surface as soon as the binder commences to go, that is the weak portion of the road. The uneven shape of the larger portions of the rock, giving more lever arm, is more likely to loosen than where the stone is smaller: and also, in the taking away of the binder by the automobile, that sooner gives unevenness to the road, and in my experience and judgment that is the first part of the road to go.

Mr. Johnson: You are talking more of individual stones, I think; but it would be different where you have a patch of say fifteen or twenty feet. Of course, it is soft limestone I am talking about, and we would not use it if we could get anything better, and under those conditions I would always suggest putting the larger pieces on top.

Mr. Morrison: Would the wear on the soft material be enough to furnish new binder?

Mr. Johnson: I would say, in reply to this, you will find, if you harrow the material, that if you get a piece of stone lying say on end it will tip round and work to the top, and after it gets to the top it will knock out; but if you harrow you will find it has a tendency to edge up and give a larger surface, then you come with your roller and down it goes, and you have the most compact conditions you can get. The road is firmer when it is thus keyed together; but if you separate them, and put a lot of binder all round them, as soon as the binder goes the road goes, and for that reason the road should be firmly made before the binder goes on it.

Mr. R. H. Thomson: I would like to call attention to the program for to-morrow. It will be a great day, and a day to justify the presence of a thousand people from King county alone. We ought to have an address from **Prof. Clifford Richardson,** of New York, who is the recognized standard authority regarding all matters relating to asphalt. He is going to be with us to-morrow, to give us a short talk on Asphalt Macadam Roadways. He is going to tell us what he believes, and as a rule after eight or ten years' discussion we have found out that he was right in the beginning. He is recognized as the standard authority in the world. We have with us **Mr. E. Purnell Hooley,** of Nottingham, England, who is the

inventor of the use of tar in connection with road surfaces in England, being the patentee of the tarmac process. When Mr. Hill took us to Paris to attend the International Road Congress, he also took us into England, and I spent two weeks there going over the roads part of the time with Mr. Lancaster and Mr. Hill, and we visited these roads in the vicinity of Nottingham. We went all through what was the old Sherwood Forest, where Robin Hood held forth, and we found there roads of remarkable beauty and remarkable strength, built by Mr. Hooley. He has consented to come all the way from Central England to Seattle, and to tell us how he built those roads. He will be with us to-morrow, and if you have any friend or neighbor who is interested in road building we have in Mr. Richardson and Mr. Hooley men who will interest them. If they want to know anything about the modern methods of using a binder which is slightly plastic, these are the men who stand on top and are the world's authorities in those matters.

We are also to have **Mr. Harold Parker** of Massachusetts. Mr. Parker was taken over some of the roads in England, and has purchased a machine to work the roads as nearly as possible after the same manner as that in which Mr. Hooley makes his roads. **Mr. G. W. Kummer** will speak on Vitrified Brick. **Mr. Lancaster**, who, as you know, is an artist in road construction, and has gone almost all over the world, is going to give us a paper on Boulevards. This convention is a wonderful school, and everything that has been said here to-day, though it may seem dry to men who are not interested in the movement, is more than interesting to those who have the movement at heart. The men who are interested in this movement must be possessed of great patience, and they must also have the necessary grit, which I think you all have.

WEDNESDAY, July 7th, 9 a.m.

Mr. Samuel Hill: I have much pleasure in introducing to you **Mr. John C. Lawrence,** who will preside over your deliberations this morning. He is a member of the Railway Commission of the State of Washington, a farmer, a banker, and last, but not least, a Good Roads enthusiast. Nobody has done more for the highways of this state, both in season and out of season. I am introducing to you a man who combines in one, railway man, farmer, banker, and Good Roads expert.

Mr. Lawrence: I am very thankful to the biggest Good Roads man in the state of Washington for having given me the honor of presiding this morning. It is certainly an honor to be present on an occasion of this kind, an event that will live long in the history of the Good Roads work in this state. I think we cannot blame any resident of the state of Washington for being enthusiastic in the matter of good roads under the leadership of Samuel Hill. (Applause.)

Mr. Lawrence then introduced **Mr. George W. Kummer,** of Seattle, who read an interesting paper on the subject of

VITRIFIED BRICK, ITS CONSTITUTION AND MANUFACTURE.

"Vitrified Brick, Its Constitution and Manufacture," is a subject broad in its scope and carries with it in its technical and mechanical application many features, governed, in part at least, by conditions present in different localities.

The primary element of a vitrified brick is a suitable clay, a mineralized clay, a clay that has annealing qualities. To lay down an inflexible rule as to what this clay should be, as by a chemical analysis, or to be specific in the matter of manufacture, as relates to the entire field of the brick industry, would be but idle words. There are no two veins of clay that are alike in their elemental structure, and therefore a corresponding latitude must be given in the discussion of this question, and which, from the nature thereof, must be treated in a somewhat general way, or else I would feel that I was overstepping the bounds of propriety, and the very argument used might prove disastrous if generally applied. To meet the conditions of the subject-matter, the clay must make a brick that—as our good engineer tells us—is free from lime, free from

laminations, spalls, checks, and cracks, that is homogeneous and impervious to moisture, and that is vitrified. It must not lose more than a certain percentage in a so-called standard rattler, it must not absorb over a given percentage of water in a specified number of hours, and its specific gravity is fixed. Here we have defined, arbitrary laws quite universally adopted.

I must take the position, perhaps boldly, that it is impossible at all places to successfully manufacture perfect vitrified brick within the limits of defined specifications that are universal in their application; and I furthermore assert that high-grade vitrified bricks are liable to fall below their entitled standard in value, because of what I am obliged to call inconsistent extremes in the matter of absorption on the one hand and the rattler test as the other extremity. I repeat that all clays vary, not alone in widely separated districts or portions of our land, but in the same locality as well, and therefore it is a physical impossibility, without restriction to territory, to produce uniform brick that will show their best results under one defined system of testing, wherein the limits are set with no regard to the physical conditions of the material.

I repeat that, in the first place, a suitable clay, a mineralized clay, if you please, is required from which to make a vitrified, or what I prefer to call an annealed, brick. Secondly, the proper grinding of the clay and the perfect formation of the brick in the green state are absolutely essential. A vitrified brick of suitable clay, properly made and finished, is in itself an iron-stone substance. By chemical action and changes during the various processes of manufacture, the constituent elements of the clay have been converted into new forms, and the finished brick is a homogeneous mass, free from lime as an active element; is annealed, every clay particle being bonded; in short, such a brick is an igneous rock, dense in its structure, practically impervious, resisting abrasion, and yet retaining grittiness in its structure, and in contact has an attractive force for steel and iron, and is enduring to the end of time as against the deteriorating agencies of the elements.

It is a well-known fact that shrinkages of varying degrees occur in clays. To make the highest quality of vitrified brick, uniform shrinkages must be had. It should be a clay that by the lapse of ages and under earth pressure has been purified by chemical processes in nature's wondrous laboratory. Such clays are found in rock or shale form. It may be possible to make vitrified brick from a single clay, guaranteeing absolute uniformity of structure, or it may be possible to blend clay and a silicate to insure density and overcome porosity. Analyses of clays are common, yet I hold that the only true test, the only safe trial, of a clay, is the manufacture of a sufficient quantity of brick for a burning in a regular kiln, in the regular way, and tried out by the only infallible chemist known, that mighty agency, fire. Though analyses are very similar of clays from different parts of the country, yet they cannot be accepted as a safe guide as universally applied. The relative quantity

of silica, alumina, iron, lime, magnesia, etc., may be set down as practically from the same clay, yet the active elements are not the same, and a perfect product is impractical. It is a well-known principle that, during the burning of clay in high heats, the silica and alumina form a silicate of alumina, which becomes the basis of the ware being made, and here comes the diverging point as between a fire brick and a vitrified brick, and, literally considered, I want to take issue with statements I have seen to the effect that fire clay vitrified brick are made. If a clay will make a fire brick, it cannot make a vitrified brick, and the difference in the chemical action or bonding of the clay particles is an illustration of what a vitrified brick really is. In a fire clay, the percentage of silica and alumina must be in such proportions that the iron and all other deleterious matters combined cannot successfully attach and disturb or unite with the basic matter; or, on the other hand, for a fire brick, when the silica and alumina are held in bond, there cannot be an excessive amount of silica, else it becomes a free agent, and, uniting with the other fluxes, becomes a destroying agent, and the basic matter is dissolved. If this destroying element is not present in a fire brick, then such brick, though thoroughly bonded, is porous; in short, has lungs, through the medium of which such brick has respiration, meeting the demands of contraction and expansion, but under impact or abrasion lacks physical strength. If this condition, as above set forth, is present in a so-called clay, perfect vitrification or annealing cannot take place. I have seen shale clays, highly refractory, that, when the point of fusion was reached, the entire mass of clay became honeycombed, and when drawn from the kiln such brick floated on the surface of the water like cork; whereas, brick made from clay from another part of the country, yet in chemical analyses much like the former, when brought to the same degree of heat, melted and made liquefied clay, or, if you please, vitrified molasses.

To make a good vitrified brick, I claim that the basic matter must be a silicate of alumina, and the action from this point of amalgamation must be the reverse to that of making a fire brick. There must be a sufficient percentage of the basic matter to give a heat range, guaranteeing against fluxing when during the burning the crisis is reached of initial vitrification and melting. Yet a suitable clay for the manufacture of vitrified brick, whether a single product or a blend, must contain sufficient quantities of flux, of iron, etc., so that the necessarily inherent quality of refractoriness is overcome, and a perfect amalgamation of clay particles takes place, giving the brick uniform structure, making it homogeneous and impervious. Personally, I cannot lay too much stress upon the absolute necessity of a uniform clay in the point of shrinkage, for in bricks made of clays that have different shrinkages the clay particles cannot be uniformly or cohesively bonded. Nor can brick made from such a mixture be burned perfectly, for clays of varying shrinkages must be measured according to the degrees of heat that they will endure before fluxing, and can only be carried

in the heat range to the degree which the weakest portion of the clay mass will endure. Otherwise they will be structurally weak. In outward appearance they may be high-grade, and they may even do themselves credit in the rattler test, as now so universally applied. They may even be tough, and particularly so when dry from a kiln. Again, brick made from such mixed clays are more subject to laminations, owing to the unequal state of plasticity, and when in service, and after exposure to dampness and the action of the elements, and the constant impact of travel, the weak spots manifest themselves, and the brick spall and shell off by reason of imperfections which cannot exist where a perfect bonding of clay particles is present throughout the entire brick, as is the case when a single clay or a blend of uniform shrinkage is used.

Having a suitable clay, the preparation thereof for brick making in the first step—i. e., the grinding—is an important one. Usually the shale or rock is reduced to small pieces by being run through a rock crusher, or, as in some cases, it is fed directly into what in the trade are known as dry pans, where it is ground into degrees of fineness as the manufacturer may direct; but I do not deem it important in this paper to go into detail in the mechanical operation of brick making, only as to some special features as these points are reached in this discussion. The grinding of clay, however, I hold to be very important. If there is uniform fineness in the clay particles, the degree of fineness being governed by the character of the clay used, a uniform bond will result; but if the clay is not uniformly fine, or is not uniform in quality, there will be voids, and perfect amalgamation of particles will not take place. Nor is it possible to produce as strong a body, or as perfect a brick, from a coarse ground clay as from a clay that has been reduced to flour form. The ground clay next goes to the tempering mills in a dry state. In these mills water is ground into the clay to bring it to a degree of plasticity so that the brick can be formed, and that they will have sufficient strength of adhesion of clay particles, so that they can be handled safely and will bear sufficient weight to permit piling on cars to be carried into tunnels, where the water that has been ground into the clay is again driven off.

From the point of the dry clay in powdered form to the dried brick, the product has passed through very important stages that have much to do with the quality of the finished brick. In the tempering of the clay, during which the water is ground into the clay mass, the subject of uniformity of action again plays an important part. While primarily this process is for the purpose as above set forth, yet another very important factor in the brick structure here manifests itself; for it is during the time the brick is being formed and dried that the first or initial bonding of the infinitesimal particles takes place, and it is a self-evident fact that if the clay mass is not uniformly moistened, or not sufficiently moistened, there cannot be a perfect and uniform bond, an essential to perfect brick. No more can nor will clay particles form per-

fect cohesion when not uniformly tempered or properly moistened, nor if of widely varying degrees of fineness, than will a cement of similar degrees of irregularity in fineness set perfectly. It is during this stage of drying, when the mechanical water is being driven off, that the first shrinkage of the brick takes place; the degree of shrinkage from the original size being governed by the character of the clay used, and therefore beyond the power of any set rule that can be laid down to control. Before following the brick to the next stage beyond the point of drying, I want to go back in the process of manufacture to the clay in its tempered state and now being put into brick form. This, as is well known, is almost without exception through what is known as a stiff mud brick machine process. The tempered clay is fed into a steel case, of varying diameters, according to the capacity of the machine, and through the center of which case or cylinder is a revolving shaft, to which are attached knives or blades, by the movements of which the clay is forced into and through dies from which columns of clay issue in continuous lengths, and which columns are, by mechanical device, cut into brick size and shape. There are two styles of dies in use in forming these clay columns in the manufacture of the so-called standard size brick, which are approximately 2½" x 4" x 8½". In one instance the column issues and is cut crosswise every 2½ inches, this making what is known as "side-cut brick." In the other case, two columns of clay issue from the die, the columns being cut every 8½ inches, this making what is known as "end-cut brick." It is during this process of forming the clay columns that laminations in brick, if they exist, have their inception, and it is in this mechanical construction that I maintain that special care should be taken in the form or shape of the knives or blades, and particularly in the construction of the die in point of lines of issue guiding the clay. I maintain that every clay has its own peculiar characteristic, and that dies constructed on the same pattern are not fit for general use. The degrees of plasticity or refractoriness of the clay must be thoroughly understood before the lines of a suitable die or issue can be safely drawn. Again, it is not a safe plan to indiscriminately use a lubricated die, for some clays make a better brick when a dry die is used. In a lubricated die, the issue of the clay column is absolutely free in all points of contact with the metal, giving no side resistance in the issue; whereas, there are high-grade clays that demand this retarding influence to give the best internal structure to the brick. This same principle carries back into the brick machine, and should be the determining factor as between side-cut and end-cut brick; for I maintain, as has been proven by actual experience, that all laminations can be avoided in vitrified brick by a study of the clay, and the construction of mechanical appliances that are suited to the clay, as against the far too common practice of trying to make a clay suit the machine, just because it makes brick successfully somewhere else and the machine man told you so. Furthermore, while I know I am treading on disputed and possibly dangerous ground, yet I want to assert as my belief that a better standard size brick can be made, with prop-

erly constructed die, in end-cut form than if made side-cut, even if the side-cut is re-pressed and the end-cut is taken directly from the machine. I take this position because in the side-cut article the clay issues approximately 4 inches thick by 8½ inches wide in a single column, which is cut at right angles through the breadth of the column; whereas, the end-cut brick columns, two to the issue, divided in the die by a steel center, issue 2½ inches wide and 4 inches thick each, and are cut through the narrow column, the clay formation in the brick running with the column, whereas in the side-cut form the clay formation is cut at right angles and severed for each brick thickness. Furthermore, it is a far simpler thing to construct a die that will control and thereby guard against twists and laminations in slender clay columns than to overcome the same condition in a greater mass of clay in one issue. After the brick has been formed, it is common practice and often required to re-press the product. Outside of shaping up the edges, or of forming lugs on the brick, or of stamping the name of the maker upon the product, the re-pressing has no value, and it is an open question, at least in the case of some clays, whether it is not an injury, caused by the sudden blow of the re-press and the almost instant release of the pressure that is put upon the brick. Referring again to the brick during the drying, the same inflexible law of conditions and quality of clay in respective districts controlling, the one general principle that is most important is the time required and the time allowed for perfect evaporation of the mechanical moisture. No limit can be set for this as a universal rule to be observed. But the essential feature of this process is that the drying shall not be unduly forced; for it is during this season that the clay particles are cohering, and if this process of knitting is forced a perfect bond cannot result. A brick that is to be carried to a state of vitrification must have all the elements of perfection at the stage of coming from the dry kilns. It must have had the advantages of perfect and free circulation of air in the kilns, with increasing degrees of heat from the green state to the dried product, which is accomplished in modern brick driers by mechanical devices that operate most successfully to thermometer tests; the heat for this purpose now almost universally being drawn from kilns that have been finished and where the firing has ceased.

From the drier, through which the brick have gone on steel cars, the driers being in tunnel form, the brick are taken into a cooling room, where they remain until they can be handled by men, when they are set in kilns ready for the final treatment by that element, fire, which is one of the greatest destroying agencies, and yet makes from a true clay one of a very few things in existence that is not destroyed by the action of the elements, namely, vitrified brick. There are kilns of many styles, yet the true principle of a kiln is that it shall have a free draft. There are many ramifications in flues through which the heat is drawn; the principle being to so hold the heat and to so distribute it as to equalize it throughout the mass of brick that are being burned within one chamber. The important feature of this construction is that the flue space shall be

adequate to the area of the chamber in which the fire shall be controlled. The brick are set or piled in height according to what the clay will endure, and the manner of setting is again controlled by the nature of the clay forming the brick. Again do I hold that each separate clay must be understood before suitable kilns in all their details can be built for its successful burning, which in its essential feature is the draft area and the application thereof. During the burning of the brick, the mechanical water not eliminated in the driers is now driven off, and this, in turn, is followed by the elimination of the water held in bond in the chemical composition of the clay in its original state; and here is where the final shrinkage of the brick in the interlacing and knitting of the clay particles takes place, and it is here where clays of excessive shrinkage, or where mixed clays of uneven shrinkage, or where impure clays come to grief, or leave their damaging effects within the finished product. It is here, also, that the stability of the clay is tested in the matter of initial vitrification and melting. It is imperative that a clay have a fair range of heat in this respect; for, if this margin is limited to a narrow basis, it is almost impossible to bring about uniform or satisfactory results in the final firing. By ingenious and thoroughly practical devices now in use in modern brick plants, the elimination of the water by absorption, and the water in bond, is noted during the progress of burning. The degree of heat in all important portions of the kiln is also recorded constantly, from the light firing as an initial burning to the point of vitrification, and the measure of shrinkage that the brick is undergoing during the firing is carefully noted; these combined observations being a safe guide to the operator in charge. The word of caution that may here be spoken, with the ever-present varying conditions of clays and what they will endure, is: Do not force the firing beyond what the clay being burned will stand with safety; for, if you do, the opened kiln will not defend your action.

We now come to the final act in the manufacture of vitrified brick; i. e., the cooling of the semi-molten mass. Here to be safe, to get the best product, the manufacturer must set aside the desire for gain, must turn a deaf ear to the clamor of contractor, engineer, or layman, who may be crowding him, and let nature take her course; for, as it is imperative during the burning to let the heat soak into and through the brick naturally, and not under forced draft, so must this heat be permitted again to pass away. It is now that the work of making structure is taking place, and the mass is being annealed and toughened; and if this is checked in the slightest degree by too sudden cooling a weakened and imperfect, or a brittle, product will be the result, but if permitted to work out under natural laws, with every condition present for the good, a product will come forth, as comes in many places and in ever-increasing numbers, that is not excelled—no, not even in the mighty workshops of nature.

"How may a man tell a good vitrified brick when he sees it?" is a question that was asked me in connection with this subject-matter, and I am pleased to answer in this way:

Establish what is the average size of a satisfactorily burned vitrified brick, made from any given clay; for all uniformly made brick, of uniform clay, uniformly burned, must be practically of uniform size when finished.

Test by absorption.

Establish a machine or device that shall hold the brick in place as they are in service, and test by impact and abrasion as under traffic.

Then put a hammer into the hands of a practical inspector, who holds his situation by reason of his knowledge of the thing you want him to pass judgment upon, and let this hammer, by test of sound and by the fracture of the brick, determine the quality, as can very easily be done when once the grade of any defined material is established; and this quality lies entirely in the brick structure, and is not governed or may not be determined by simple shades of color, for it must be remembered that any clay that will vitrify cannot be burned to an absolute shade in color, unless the degrees of heat are practically identical throughout the entire kiln area, which has never been possible, as measured from top to bottom of the kiln, even in the burning of the highest grades of face brick, where uniformity of color or shade is much desired. I said above: "Test by absorption." But this must have its limitations, for vitrified brick will vary in the percentages of absorption from nil to various quantitative proportions, according to the degrees of heat to which they have been subjected in their relative position in the kiln during the burning, which is but a natural result of the absolutely essential element in clay of heat range between the point of initial vitrification and fluxing. The matter of absorption, the limitation to which it may be extended, here becomes an open book, and can readily be determined as a safe guide in tests and to guard against overburned brick. The hammer in the hands of a competent man is ever sufficient.

Finally, gentlemen, we have in a vitrified brick, as I have endeavored to describe, a material that in structure and enduring qualities is not surpassed by any known material; for it is not affected by heat or cold, is not amenable to the deteriorating influences of the elements, and is as lasting as is the lava that was emitted from the crater's mouth and has endured for centuries, and which has given us our first lesson in vitrification at the hands of the Great Creator, and, furthermore, have we our lesson from Him in the matter of the necessity of using a clay that has by nature been refined, for

> The Lord in His wisdom showed us the way,
> For He made Adam from virgin clay,
> But when He beheld the Figure Nude,
> He said, " 'Tis well, but still quite crude."
> So from this mold of earthy clay,
> Now freed from dross on this Hallowed day,
> He took a rib, no longer mud,
> But now infused with mineral blood,
> And lo! behold what this pure clay did make;
> 'Tis said one, and only one, for each man to take.

Mr. Samuel Hill: I make a motion that the Congress do now adjourn and walk out and see this brick put in place on our piece of experimental road. You will all be interested I am sure to see this vitrified brick.

On the return of the delegates to the Good Roads building, **Mr. F. N. Godfrey,** of New York, read a letter from **Mr. James H. MacDonald,** Chairman of the Highway Committee of the State of Connecticut and President of the Road Makers' Association of that State.

Mr. Godfrey said: I have here a letter from my personal friend Mr. MacDonald, which perhaps it was not intended that I should read; but I feel it is almost too good to keep, showing his sympathy with the work of this Congress.

Mr. MacDonald's Letter.

Mr. F. N. Godfrey,
c/o Samuel Hill,
Seattle, Wash.

My Dear Mr. Godfrey:

It is with sincere regret that I shake hands with you across the continent, when I expected to stand with you and enjoy the pleasant occasion together; but the Legislature, which is still in session and is liable to be for some time to come, has delayed action on my good roads matters to the extent that it is impossible for me to leave the ship at this time.

The entire future of the good roads movement depends on my staying very close to the laws I have presented for consideration by the committee until they have reached a safe harbor. I do not think I will grow less in your estimation by taking this course. My first duty is to the work of my department, for the reason that future generations' comfort, happiness, convenience, and prosperity depend very largely on the good roads law being adopted along those lines that will make for progress and be permanent in their character. So many years of hard work—fourteen years in July—demand that at this critical time I should not absent myself one moment from careful oversight of these bills, so that they will come from the committee and go through the Senate and the House as I have recommended.

As much as I regret my inability to unload the duties of my office for three weeks, I cannot, in justice to the future of this movement, absent myself and neglect my state work for my own personal pleasure.

My heart lies very close to Mr. Samuel Hill in his splendid work for the reclamation of the roads on the Pacific Coast, and I would go a great many thousand miles to hold up his banner—yes, even

to carry one of its tassels—to assist him in the laudable purposes he is engaged in.

I have written him a letter, without going quite so much into detail as with you, simply relating the facts and relying on the strong bond of friendship that has existed between him and me. I hope you will not feel disappointed at my absenting myself from this convention and being present with you personally in its deliberations.

I trust you and I may meet on some similar occasion. I have in mind holding a convention on the part of our association later in the season, at which time I hope to have you speak, as a little softening of the blow at not being able to be with you on the Pacific Coast. It is a hard matter, Brother Godfrey, to tie myself down here just at this time, when I want to be with you; but my official work is such that I cannot leave it.

I am writing you this letter, so that it may reach you at the time you are holding the convention, and thus know that the State Highway Commissioner of Connecticut is present in the spirit, although absent in the body.

Very sincerely your friend, JAMES H. MACDONALD.

Mr. Lawrence: There were a number of questions asked of Mr. R. H. Thomson concerning the laying of the vitrified brick, and at the suggestion of Mr. Lancaster he is requested to repeat his statements at this time, so that they may appear in the record for the benefit of those who hereafter may have the pleasure of reading the proceedings of this Congress.

Mr. R. H. Thomson: I was asked a great many questions, while we were down looking at the sample roadways, about methods of construction and cost of construction. I presume that each one of you will recognize that neither the same method of construction can be used in every place nor will the same cost of construction prevail, because of differences in the hours of labor and the cost of labor and material.

We use four different classes of paving in Seattle. The first is stone block pavement, which is of two kinds, granite and sandstone. We have some granite block pavement laid where there is very heavy traffic in the neighborhood of the freight yards. It gives only a fair foothold, and has a tendency to become quite noisy, and because of the extreme noise we do not consider it adapted to any street on which there is any considerable trading being carried on, especially retail trading. That pavement, however, costs us about fifty cents a square foot for the finished roadway, taking into con-

sideration the cost of excavation and the cost of the curbs alongside of the street. It is often a good thing to know about what the cost of the finished roadway will be, taking into consideration everything, and not taking what you would call "pot luck." When going into the construction of a piece of granite block pavement in the streets in Seattle, we include the removing of the subgrade and the relaying and the laying down of drain tile; for we consider that without a solid foundation the paving is worthless. We drain out, and put in gravel, and take the drainage into catch-basins. Including a six-inch concrete base, sand cushion, cut stone topping, and granite curbs, and all incidentals, the average cost of a square foot of granite pavement is fifty cents.

On steep hills, to give a better foothold to the horses, so that the horse's shoe will have a grip, we are using sandstone. We do not expect it to last very long, but it is a question of absolute economy. We figure with pencil and pad as to which is cheaper—to allow the teams to only haul 3,000 pounds as a load for a team on asphalt or brick, or to put on a rough, gritty surface, and allow them to haul 5,000 or 6,000 pounds. When you can practically double the load by putting in the pavement which will give the better foothold, it is more economical to the citizen to put sandstone than granite, brick, or asphalt, because there is the better foothold, and the teams can carry greater loads. We would not recommend this for trotting traffic, because it is this trotting traffic that destroys pavement of any kind. Walking traffic does not destroy practically any pavement. Take a heavy horse, and as he walks he shuffles; but when you get a trotting horse, and he begins to go over the street, and lifts his foot, and comes down, and cuts it, and digs into the pavement, if it is sandstone, he hollows it out and destroys it, and trotting traffic is the traffic which is so destructive. Walking traffic will do very little destruction to any good pavement.

The second class, vitrified brick, is what you saw on the roadway. This piece of roadway we hope will be part of a general boulevard to be carried through the University ground around the shore of the Lake, and we hope to put in samples of every class of pavement that we are laying for the study of the Good Roads and Engineering Department of the State University, so that we can make an actual, unprejudiced, and scientific study of the cash value of all the different sorts of pavements. That is why you see the brick, wood

block, and asphalt, and if Mr. Hooley has brought samples, and if Prof. Richardson has brought a big enough box of asphalt macadam we will lay it. We want to get samples of a reasonable length of every class of pavement we can put in.

We are laying this brick with a six-inch concrete foundation, and on that, unless it is laid on gravel, or a porous soil, we place gravel, and put in drain tile, and carry this over two hundred and fifty or three hundred feet, so that the subsoil may be absolutely dry. We put on the six-inch concrete foundation after the subsoil has been rolled with a fourteen-ton roller, and we roll it down until the roller has absolutely got tired. Then we put a sand cushion, about one and a half inches of good clean sand, and then the brick are laid, as you saw them there; and as a rule we put a one-inch plank over the section, and put on the fourteen-ton roller, and roll the street, pressing the brick into the sand under the plank, and when we get through we have an almost uniform surface, and the sand has been pressed down from one and a half inches until it is only about three-quarters or one inch, and the crevices we fill in different ways on different streets, according to the desire or fad of the abutting owners. Personally I believe that hot sand filler is as effective as anything that can be used. We take the fine, sharp sand, and heat it very hot, and then spread it on the pavement, and sweep it into the crevices, and it runs. You have heard how hot molasses will run; hot sand will run just as well. It binds the brick together, so that to lift the brick out we have been compelled to take a hammer and break the brick to make an opening, and have had to use a hammer and cold chisel to get in. It becomes so dense that it is impervious to water, because we wash every night with a hose, or rather we did for years, streets with the sand filler only. We put the hose on a hydrant with eighty pounds pressure and the sand filler remained. That applies particularly to Second Avenue from Pike Street to Yesler Way. This we laid in 1896, and there is one half block of street in front of Frederick & Nelson's store on the west side of the street which has had no disturbance from that time to this. You can see this half block which has been undisturbed for years, and that will give you the best idea of a vitrified brick pavement with sand filler. Taking that kind of pavement, which costs us, including all incidentals, such as catch-basins, six-inch concrete base, and all the other paraphernalia, forty cents per square foot, our con-

tract price has been $2.45 or $2.65 per yard; but, when you add all the other things that go with it, excavation, drain, catch-basin, curbs, etc., it runs up to forty cents per square foot.

We will now take our asphalt pavement, principally in the residential districts. There it is our purpose to give roadways twenty-five feet wide, nicely crowned, about four or four and a half inches in twenty-five feet, with concrete curbs, and four to four and a half concrete base with subdrains—because we subdrain the asphalt the same as anything else—and one to one and a half inches of binder gravel coated with liquid asphalt laid on top of the base, and between that and the one and a half inch wearing surface; and the wearing surface, the average cost, taking everything into consideration, has been thirty-two cents per square foot. Recently we have been getting some contracts as low as $1.60 to $1.75 per square yard, which gives the appearance of a much less price; but to this price there must be added the cost of the earth excavation, the subdrains, catch-basins and curbs, and I have no doubt every one wants to know what this costs for the finished street. That was taking an average price running over twelve or fourteen years. The granite and sandstone costs us practically fifty cents for the finished street, everything made and laid; the vitrified brick, forty cents; and the asphalt between thirty-two and thirty-three cents—being in each case for the finished street. If you take these figures and bear them in mind, you will not be deceived by hearing the cheap figures as to cost per square yard and claiming that it costs more than it should. It costs about thirty-two cents per square foot for the best asphalt.

As to the wearing qualities of asphalt, the first street was constructed seven years ago on Ninth Avenue from Madison Street south. That street to-day for nearly half a mile looks as well as if it had only been laid two or three weeks ago. It was laid of the best tested Alcatraz asphalt from California. There are two streets in the city laid of asphalt which never were successful. The asphalt burnt before it was laid down, and they are still being repaired. They are the north part of First Avenue and a considerable portion of Broadway.

On Capitol Hill we have one of the streets of the city which has not yet been accepted. The majority of the streets of Capitol Hill have been laid about five years. They are between 25 and 32 feet in width between curbs, and have cost an average of thirty-two cents

per square foot complete, laid on a concrete base, with subdrainage, and with the exception of Broadway, which, as I say, we are still working on after four or five years, some of the asphalt having been injured in the original refining, and there not having been quite enough asphalt put into the mixture, with that exception, friends of mine have offered a dollar for any crack that could be found in the whole territory, and no one has yet earned the dollar.

We have been remarkably successful with our asphalt pavement, largely through the co-operation of one of the gentlemen who is going to present a paper here to-day, Prof. Clifford Richardson.

Mr. Campbell: Do I understand that the pavement is all laid by contract under city inspection?

Mr. Thomson: We inspect everything, and the asphalt is tested continually in our laboratory under standard specification.

Judge Hanford: Is there not a part of Capitol Hill where the asphalt was laid by private owner?

Mr. Thomson: There is a portion of the district known as Capitol Hill where what appears to be asphalt pavement was laid down by a landowner prior to the sale of his plat. Permission was given for the landowner to make his own improvements; but he bought what is known as bituminous rock, which is sand into which has filtered asphalt. This was brought here from California, and is frequently mistaken for the real asphalt pavement. There is a good deal of complaint about the bad appearance of this bituminous rock pavement in the Capitol Hill district. I know them so well, and always pass round the corner, so as not to see them, and for that reason I never think of them as being part of the city's work. They show the danger of allowing a private landowner the privilege of pretending to improve his property before he sells it. He charges about twice the price it would have cost for the city to have done the work by reason of the pretended improvement, and as a rule the citizens who purchase get about a quarter of the actual value. These supposed improvements are a positive injury as a rule, and disgrace the profession of road making.

Mr. Campbell: Do you lay the asphalt up to and between the rails of the street railway?

Mr. Thomson: We lay none of the pavement further than one and a half feet of the outer rail of the railway. We put it up to the

street railway company to lay that one and a half feet, and to lay between the tracks, and to maintain it. As a rule they use headers, toothing out from the rail on the outside, and they fill in from our pavement to within and between those headers, mostly brick. At the present time they lay two or three rows of brick parallel with the rail, and they are thus able to lift them and tighten the joints without destroying the asphalt pavement, and to drop the brick in position, using the hot asphalt or whatever they may use.

Mr. Campbell: Do you allow them to use their own material?

Mr. Thomson: The franchise says they shall use the same material; but it is not always possible to put the same material up against the rail that you put in the middle of the street. For instance, in some of the cable roads, we have been compelled to permit them to use a thin granite block, and to crowd that in between the rails, because, unless we destroyed the entire track, their construction would not permit the use of our material. In passing over the steel rail, if the asphalt were immediately adjacent, the tendency would be to plow it out by passing from the harder to the softer texture, and we permit them to put these headers of brick right along the rail, and frequently to pave within the track with brick entirely, because it gives practically the same foothold.

An Inquirer: Can you recollect what material is at the junction of Broadway and Madison?

Mr. Thomson: That is a part of the asphalt that was put in some five or six years ago, of which we have been complaining. It is not a bituminous rock, but it is an artificial asphalt. I think the worst-looking intersection on the whole street is Columbia and Broadway; but the whole street is defective from one end to the other. The asphalt had been burned. It is the residuum of the distillation of crude petroleum, and there is very considerable free carbon in the mass, which tends to its destruction. We have laid brick gutter and asphalt gutter, and I am not quite sure whether the asphalt gutter is as good as the brick.

An Inquirer: Do you continue the asphalt to the curb?

Mr. Thomson: Yes; we are practically coming to that, as I believe it makes a more symmetrical and an equally valuable street as when we put the cut stone along the curb. We originally fol-

lowed the English practice of laying cut stone or brick along the curb.

Mr. Campbell: We find the sheet asphalt cracks, splits, and opens out. I do not notice that here. Can you account for it?

Mr. Richardson: I am very familiar with Toronto, and I will explain this when Mr. Thomson is through.

Mr. Campbell: I would like to ask what woods you have been experimenting with in your wood block pavement

Mr. Thomson: Cedar and Douglas fir. We have found wood block paving in our climate has been unsatisfactory in two respects: First, it was creosoted sufficiently to be quite antiseptic, and was very slippery on our grades, so that the horses could not stand, unless the street was kept sprinkled with grits; and I find that true of every road of wood block that I have investigated anywhere in the world. I spent some time in London and in Westminster, where they use a wood, which is not very different from our Douglas fir, and it costs them $1,000 a year simply to place in boxes alongside the street the quantity of grits necessary for the street men to have in their hands to spread upon the street surface to prevent the horses slipping. It costs them this amount for every mile of road. Then again the wood block varies so in texture that they will make ruts and depressions, and then again the wood pavement becomes very offensive under heavy loads. It is necessary to wash and sweep the wood pavement, and the upper portion of the block holds the water, and when a heavy team goes over it that water sprays out of the side, and the dirty spray will dirt everything alongside. You cannot prevent it in the nature of things, so in our climate, with our moisture, and with our hills, we have not favored the wood block pavement. We make no objections to its use by those whom it suits. We know that in European countries, for instance, in the city of Paris, they do not expect a wood block pavement to last more than three and a half years; but they say they can afford to put it in because of the quiet which it affords to the shopkeepers on the side of the street. A shopkeeper told me in Paris that they once had stone pavement, and you could not hear yourself think, let alone speak, and it was impossible to carry on any trade. If a lady wanted to buy some laces, for example, the shop girl who was was showing her the things on the counter would have to make a megaphone by putting her hands to

her mouth and crying out to her the price, and if she started to make a special rate, just as she was calling out, "I will make you such and such a rate," there would be a difference in the noise in the room, occasioned by the fact that some wagon or vehicle had stopped, and all through the room it would come like a trumpet blast the special rate that she was making. To get that quiet and to avoid annoyance they put in a wood block pavement, and they say that it pays in quiet and increased rentals. They can take it away every three and a half years, but they have to sprinkle it with grit or sand every morning.

Mr. Campbell: Under the conditions you describe, you think wooden pavements might be satisfactory?

Mr. Thomson: It is certainly very dirty. I do not know of any more offensive place than some of the streets in London where wood block paving is used, nor a harder place for horses to travel than where hardwood is used. It would have to be covered with grits all the time, and is very expensive.

Mr. Campbell: Do you use these subdrains on the top of these ridges, where you have no higher ground around? Is it necessary to use subdrains in those cases?

Mr. Thomson: Where there is no higher ground, we do not use a subdrain; but there are very few places in Seattle where there is not higher ground. On some of the level streets of Capitol Hill, we have found it necessary to lay subdrains, even though the ground appeared to be very little higher. There are some of the streets on the hillside where we have not laid them, because there is some eight or ten feet of open gravel underneath the roadway, in which it is never possible to find water; but, wherever we encounter clay or hardpan and the least bit of higher ground, we put in gravel, and tile drain, and carry it off into catch-basins. When this was first done, a great many people laughed at me, and said it was ridiculous to think that water would pass under granite curbs and get under the roadway, and I appointed one of my assistants, Mr. Scott, to go out during heavy storms, and immediately after, and take off the covers of the catch-basins in places where there was supposed to be no water whatever, and to see if any water was coming into the catch-basins, and in nearly every case a considerable stream of water was coming through the drain tiles. Only in a few cases out

of a hundred did he find that there was no water coming through the drain tiles, so my belief in the necessity of tiling was fully substantiated by the result.

Mr. Campbell: Have you noticed any difficulty with the buckling of the wood blocks?

Mr. Thomson: Our wood block never buckled, for the reason that, before we laid the blocks, we put a piece of plank, a little more than an inch in thickness at the bottom and about one and three-quarter inches at the top, against the curb on both sides, and we laid the blocks against the plank. As soon as the blocks were laid, the plank was removed, and that crevice was filled with clay. When the block expands, that clay is simply raised alongside the curb, taking up the expansion; otherwise, our blocks would have buckled.

An Inquirer: In Regina we fill the spaces with tar, leaving one inch space, and that squeezed out, and this year they took up nearly the whole pavement, and left two inches space, and that is raised up.

Mr. Thomson: What kind of wood did you use?

A British Columbia fir. I am not in charge of it; but I have noticed it. That is all.

Mr. Richardson: It depends largely on the amount of saturation in the block. In New York we have no expansion; but we only put in sixteen pounds, because that gives an opportunity for some expansion. If you put in only eight pounds to the cubic foot, you have to have still larger expansion.

Mr. Thomson: It is a good plan to soak the blocks. I think we have had our last block pavement. We have no complaint against them where it is a necessity for retail shops, and where people are willing to pay any price for quiet. Those who desire them are welcome to them all over the world, and we have plenty of wood yet to sell, and the more they want the higher will be the price on the timber, so I don't want to say too much against block paving.

Mr. Richardson: What do they cost?

Mr. Thomson: A little more than brick. If brick costs forty cents per square foot, wood block will cost about forty-two and a half cents.

Mr. Richardson: Is not the question of paving in Seattle a simpler matter than in Chicago or Detroit, where the variation of temperature is so much more?

Mr. Thomson: I think it is; but, as it relates to asphalt, we are passing all these matters up to Prof. Richardson. He comes here charged with the responsibility of defending asphalt, and says he will be good-natured, whatever happens. It is much more difficult to maintain pavements of any kind in a climate of great extremes, and I think that Chicago and Toronto and Winnipeg have considerable extremes in temperature.

Mr. Richardson: I have found Omaha and St. Paul to be very difficult cities.

Mr. Thomson: Omaha is, because of the clayey character of the ground. The frost in Omaha clay seems to go as far down as a man can dig, and the frost seems to want to go straight down, and the clay wants to come right up. I cannot say I know as much about St. Paul. In conclusion, I would say that as a filler I prefer hot sand to any other filler known. When Mr. Little was Superintendent of Streets, and wanted to keep Second Avenue clean, he got nozzles and put hose on the hydrants on Second Avenue, where there was eighty pounds pressure, and he went out and washed the street with a hose, and people thought the street would be ruined. I quarreled with him very much; but that took place eleven years ago, and the street looks pretty nearly as good to-day as it did then. If I had my way, I would use the sand filler exclusively.

Prof. Clifford Richardson, before reading his paper on Asphalt Macadam Roadways, made a few remarks along the line of the previous discussion. He said:

It is a great pleasure to me to meet you all here to-day. I had not intended to introduce the subject of sheet asphalt pavement in my remarks; but, since our visit to the plat in the grounds, and the discussion of the matter of pavements by Mr. Thomson, and the questions asked, it may be worth while to take the subject up to a certain extent.

Modern sheet asphalt pavement is the development of more than thirty years' experience. It was first laid in a rule of thumb way on Pennsylvania Avenue, Washington, from the Capitol to the Treasury, and was so successful that the Commissioners in charge of the paving in the city of Washington rejected all other

methods, and it has been used there very satisfactorily ever since. Up to 1896 the construction was, however, purely one of rule of thumb. A certain amount of sand and ground limestone and asphalt was mixed together in a haphazard way and laid upon the foundation, whether of broken stone, or concrete, or whatever it might be, old pavements, or old granite sets; but I entered upon the study of the thing as early as 1887, and by 1896, owing to the experience which I had had in laying pavements in London, England, and one or two other Continental cities, I found that that rule of thumb method would not meet the trying conditions found in Continental cities. The pavements I laid in Washington and in the Kingsway in London in 1894 began to come up at one end before they were finished at the other, owing to the weather and traffic. During the course of the next two or three years we had an opportunity of continuing our experiments and working out a rational system of construction of sheet asphalt. That showed us the most important thing in sheet asphalt is not the asphalt, but the sand; and it is not alone the sand, but the character of the sand, the relation of the sizes of the different grains to each other. Each sand has a different capacity for carrying asphalt. In the early pavements we had very little filler, as we could not find a sand to meet the moist conditions in London or the heavy traffic, and we had to add an impalpable powder; the most desirable being Portland cement. Then we had to study carefully how much asphalt and cement material this combined sand and filler would carry.

Mr. Campbell has alleged the fact that the pavements of Toronto cracked badly, and that is the case in a large number of instances, and that is due to the fact that the sand in Toronto has grains of a peculiar surface. Toronto's sand will carry but eight and a half per cent. of bitumen. I have had mixtures sent from there this year which show that that is the dangerous thing. Sand in Seattle will carry from twelve to thirteen per cent. of bitumen, so you see what a local question it is to know how to handle the sands that are available. A week or two ago I wrote to the superintendent of the company in Toronto that he must find a sand that will carry more bitumen, and he has done so, until it now carries nine and a half per cent. of bitumen; but he cannot get the amount that you have in Seattle.

One reason why the pavement is so satisfactory in Seattle is the sand. It is a perfect sand for constructing an asphalt pavement, and will carry sufficient bitumen without being soft; bitumen being present in excess to give an elastic surface of a lasting property. Another reason why your pavements are so satisfactory is entirely due to Mr. Thomson. He puts a foundation under them which sustains them. We speak of asphalt pavement and the weight it will carry. It is not the asphalt, it is the foundation, that is the pavement. The asphalt is merely the wearing surface; and, if it is not properly supported, the best asphalt is of no value whatever.

In New York we have some most disgraceful asphalt pavements. It is a city of enormous area, the amount for paving is small, and they are obliged to spread it over a vast area. The principal reason of this is that they do not put in proper foundations, but lay the asphalt over the old pavements of the city, with the result that it is not properly supported.

Mr. Thomson and a number of gentlemen have remarked that there was pavement laid here in 1904 which has not been entirely successful. This had been down but a few months when I received a telegram saying we were in difficulties and to come here. My last visit here was for the purpose of studying the difficulties encountered at that time and arranging matters that would be satisfactory in the future. The difficulty was we assumed that Seattle sand should be used the same as the sand is used in the Eastern States with 10½ per cent. of bitumen. I found that the material which we were using for a filler was simply round particles of sand, which were of no advantage as a filler, and made the mixture unstable; and I had to modify it by adding to every nine cubic feet of the mixture 100 pounds of ground filler, and then we found we could run the asphalt cement up to a point where our mixture contained from 12½ to 15 per cent. of asphalt. That was determined by me in 1904, and is being successfully laid here at the present time.

I will here say that there are no general conclusions which can be applied to the construction of asphalt pavement in every town. We must discover the local conditions and meet them. There are very many general conclusions which can be drawn from the behavior of sheet asphalt pavement, which it seems can be well applied to the country highway.

Prof. Richardson then read his paper on "Asphalt Macadam Roadways," which is printed below:

ASPHALT MACADAM ROADWAYS.

By Clifford Richardson, M. Am. Soc. C. E.

It is somewhat surprising, to one who has been a close observer of the development of the modern sheet asphalt pavement in the United States during the last forty years, that so little application has been made of the experience gained in that industry to the problem of the construction of bituminous macadam highways which shall meet the conditions which exist to-day.

There should not be any essential difference in principle in the construction of a sheet asphalt pavement and a bituminous macadam roadway. Both consist of a mineral aggregate cemented together with a bituminous binding material; the aggregate in one case being fine, and in the other containing coarse, particles. Experience has shown that, in either type of surface, the mineral aggregate being of a suitable character, the capacity of the resulting

surface to resist travel will depend on the more or less satisfactory nature of the cementing material.

In the early days attempts were made to construct pavements in Washington and elsewhere with both fine and coarse aggregates, using coal tar as a cementing material. All these attempts with both fine and coarse aggregates were failures to a greater or less extent, and its use was abandoned on the advent of the form of asphaltic construction developed by De Smedt, although it was revived for a few years in the late '80's in mixture with asphalt with equally disastrous results. The surfaces having a coarse aggregate were somewhat more lasting than those made with sand, and a small portion remained in place until the end of the century. They were known as "Evans pavements," and were resurfaced with asphalt after a few years. One of these, protected by an asphalt surface, was found, on repaving Connecticut Avenue, in Washington, in 1906. A piece of it was collected by the writer and examined. A section is shown in the accompanying illustration. From this it appears that a coal tar bituminous macadam was constructed as long ago as 1873, and proved, in a short period of time, not to be a lasting form of construction. Notwithstanding this fact, experiment after experiment has been conducted along the same lines in recent years with similar results. Few, if any, highway engineers seem to have benefited by the experince of their predecessors, and most of them still have the coal tar lesson to learn on their own part, although it is evident that this form of construction cannot give satisfactory results for more than a few years.

On the other hand, referring again to the lessons of the paving industry, the modern sheet asphalt pavement, where constructed on rational lines on a rigid, well-drained foundation, has proved a complete success, as exemplified by the fact that a pavement of this type has satisfactorily resisted the heavy travel which is found on Fifth Avenue, in New York City—14,000 vehicles in the period between 6 a. m. and 7 p. m.—for a period of twelve years. In the same way an asphalt concrete surface constructed with a well-graded, but coarse, mineral aggregate in 1902 in Muskegon, Mich., which has been used as a favorite drive since that time, has been in use with no repairs whatever, where many similar surfaces in which coal tar has been the cementing material have deteriorated or required resurfacing under similar circumstances during the same period. The Muskegon work has not only demonstrated the superiority of asphalt as a cementing material, but this has been confirmed by other surfaces of the same form of construction in Owosso, Mich., in Paterson, N. J., Scranton, Pa., Staten Island, N. Y., and elsewhere.

The evident conclusion which may be drawn from past and present experience is that success can be arrived at in the construction of any form of bituminous road surface only by the use of asphalt as a cementing material. The thing to be considered however, is: How can asphalt be used in building the cheaper forms of country highways, which are now in demand to resist motor and concen-

trated traffic, where the aggregate is merely of the grading of the ordinary stone which is employed in surfacing macadam roads? The asphalt surface constructed in Muskegon in 1902, and elsewhere, was an asphaltic concrete. The mineral aggregate was well graded and in itself compact. This could only be combined with the cementing material in a hot condition, which required a plant to which the aggregate was hauled and from which it was again hauled to the point where it was put in place. The operation was, therefore, an expensive one, and makes the cost of this form of construction prohibitive for country roads. Recourse must therefore be had to some other method of combining a mineral aggregate and asphalt immediately on the spot where the surface is to be constructed.

For many years tar macadam has been laid in England, France, and, to a smaller extent, in this country in Rhode Island, New Jersey, and elsewhere. This form of roadway is arrived at by coating the No. 2 or surface stone of the macadam with coal tar in one way or another, either before or after rolling it, and afterwards filling the voids in the surface with more tar and grit, screenings or sand. Such a surface is desirable when first finished; but it soon begins to deteriorate and ravel, especially when exposed to horse-drawn travel, with the weathering and aging of the cementing material. From past experience, it is not difficult to arrive at the conclusion that, if an asphalt cement were substituted for the coal tar, a result would be attained which would correspond to the improvement which was evident on the substitution of asphalt for tar in street pavements. The difficulty lies in the fact that an asphalt cement is much more viscous than tar. It must be used in a much better condition, and does not mix with or adhere so readily to cold stone. Experiments have shown, however, that this can be accomplished by using a much softer asphalt than is customary in street asphalt pavements, or even in surfaces of the type of the Muskegon pavement. To-day we find ourselves, after some experiment, in the position of being able to coat stone, of the type used in macadam surfaces, with an asphalt cement which serves satisfactorily as a binder for such an aggregate, on a metal mixing board with hand labor and shovels, at the point on the road where the material is to be put in place, and with very reasonable economy. It produces a surface which, while not of the stability or having the wearing properties of the Muskegon type, is as far superior to the ordinary tar macadam as the sheet asphalt pavement is superior to one of the tar poultices of thirty-five years ago.

The base of the cementing material must, however, be an asphalt of the best quality, such as is used in the construction of sheet asphalt pavements; in fact, it must be an asphalt paving cement such as is called for under the strictest municipal specifications, but merely made softer by the use of a larger percentage of flux. Dense oils and residuums to which no solid native bitumen has been added will not accomplish the same results to any greater or

more satisfactory degree than they would if used in a street pavement. Further, the character of the flux in asphalt cements for use in macadam must be more carefully taken into consideration than that for use in street pavements, as the amount is so much larger, in consequence of which it has a greater bearing on the character of the cement.

On the Pacific Slope, the opportunity for the construction of roadways of the highest type, which has been described, is facilitated by the fact that vast quantities of residual pitch and flux, most of it of suitable quality, is available as a cementing material or binder, so that all that is necessary is a certain amount of skill and experience in handling it, to attain the best results. In fact, there is no part of the world which is so favorably situated for solving the road problem as the state of Washington, where stone of the highest grade is available for the mineral aggregate, and a cheap and abundant supply of cementing material from the neighboring state of California. The state is to be congratulated on the opportunities which it has in these directions, upon the energy with which the road problem is being attacked, and upon the prospects of success which lie before it.

Types of asphalt macadam roads such as have been described in this paper are given in the accompanying illustrations.

DISCUSSION.

Question: Is asphalt principally used in New York as the most popular pavement?

Mr. Richardson: There is more asphalt paving than any other type of improved street.

M. O. Eldredge: A few days ago a gentleman told me that the poor pavements in Washington had been covered with asphalt, and that was one reason why they had lasted for so many years. I telegraphed to Washington, to the Chief Engineer of our office, and asked him: (1) Have the sixteen pavements of which we have samples been covered with asphalt? (2) Have they been in continuous service? And he telegraphed back that part of the pavements had never been covered with asphalt and had been in continuous service. I would like to ask you what you know about this.

Mr. Richardson: As I was connected with the Engineers' Department of the District of Columbia for a number of years, I have some acquaintance with this matter. I have examined the specimens which you have here. One is labeled "From Highland Ter-

race," which is not a public highway, and has very little traffic. A portion of the original tar composition still stands there; but it was very badly cracked and has received a large amount of repair. The same applies to most of the other samples you have there. They are merely remnants of old pavements, and the samples are not covered with asphalt; but most of the roads were covered with sheet asphalt. I was in Washington, D. C., when Connecticut Avenue was being taken up, and it was a most remarkable sight. It looked like an old fill. They took off two or three rows of the surface until they got to the old Evans pavement. It looked like a fill in State Street, Chicago. A concrete foundation was put in, and a modern sheet asphalt pavement. At that time I collected one of these pieces of the old Evans pavement, and carried it to my laboratory as a curiosity, and had a section of it made. It is coarse stone and fine sand mixed up together, without any rational idea of grading. In those days they had no idea of the regular consistency of tar, and that sample of the old town pavement which is on exhibit in the Government Building will show you what the grading was.

Mr. Eldredge: Were those pavements built under patents?

Mr. Richardson: Yes. Mr. Evans owned a patent; but it was one of those patents where you must put so much sulphur and so much of this and that, and was of no value in the construction of these pavements. It was a patent used simply for promotion purposes.

Mr. Campbell: In my experience I have heard so many reasons given for the cause of cracked pavements and I have had my own idea of the thing; but I have heard so many reasons I would like to have your idea. That seems to be the main objection to this style of pavement

Mr. Richardson: I have alluded to one cause of the cracking when speaking of the Toronto pavement, due to the fact that the sand will not carry bitumen; but that is not universal, nor by any means the general cause. The cause usually is due to the fact that the asphaltic cement has not a sufficient amount of flux and is not soft enough. It is also due to the fact that there is not enough asphalt cement used, and not sufficient bitumen in the pavement. Those were the experiences of some years ago. In fact, during the last five years we have derived so much evidence of the stability of

the mineral aggregates in the filler used that the asphalt to-day is from 20 to 30 points softer than it was five years ago. I would say that the matter of avoiding cracks to-day is very simple, if the person constructing the pavement has had sufficient experience and is skillful enough in laying it with the information at present to be had.

An Inquirer: Mr. Thomson made a remark that a friend had offered him a dollar for every crack in a certain pavement on Capitol Hill. We have laid some pavement, and the same mixture has been used, and I recall two places where there are cracks on the hill. Why should there be a crack on the hill, and not on a level surface, from the same mixture?

Mr. Richardson: There must be some peculiarity in the foundation. If the foundation cracks, the crack is carried through to the surface. It might interest you to know why the California rock asphalt did not prove satisfactory. This was due to the fact that the sand is of one size grain. It is a sand which is impregnated with bitumen; but there is no filler, nor anything to give stability. The only way that it can be brought to a proper consistency is by heating the asphaltic sand until the excessive oil is driven out. It could not be expected that would serve well in this climate; but if that be heated, and there be the proper amount of sand, you give the minimum aggregate stability, and a good pavement can be provided, but it would require rather an extraordinary amount of skill to do it.

Mr. Campbell: We have found that after a street has been completed, and the rolling finished, the surface appears to be of a uniform character in appearance and in every respect; but a little later on, after a rainstorm, you will notice some patches here and there over the surface where the asphalt appears to have attracted the moisture just enough to show a little dark patch. Closely observing that, we find later on that the wheel seems to touch these patches or spots and a depression is caused. Later on this will hold a little water, and keeps increasing, until finally a hole appears there, which spoils the whole surface of the pavement. Sometimes I have noticed that you will find a series of these patches or blisters, as it were, and I have wondered what is the cause. I can quite understand that the greatest care should be taken in the selection of the sand; the sand forming from 90 to 92 per cent. of the

composition. Consequently much care should be taken in the selection of the sand. If a good, clean, pure silica should be selected and carefully mixed and applied, I should think that would meet with success; but I have thought that possibly these patches were caused by poor material—poor sand, or earthy matter of some description being found among the sand.

Mr. Richardson: It is entirely due to the fact that material is not properly raked out. You dump a load of material on the street, and it is one of the most important things in constructing an asphalt pavement that it shall all be loosened up and spread evenly before it is rolled. If there is one place denser than another, the roller will rise, and will not press the looser portion; and the spots you speak of, without doubt, are due to the fact that the material has not been evenly raked. The very fact that the spots appear shortly after the road is laid shows that it has not been properly pressed. I only know one town which is situated the same as Toronto as regards the small amount of bitumen in the sand, and that is Moline, Illinois. They have the two sands which will carry bitumen less satisfactorily than any other city.

Mr. Campbell: Would there be anything in the fact of the material cooling off at the side of the box?

Mr. Richardson: The portions that are cooled are, of course, more difficult to rake than the warmer portions.

(End of discussion.)

ADDRESS TO MR. SAMUEL HILL.

Hon. C. H. Hanford: It has been suggested, very properly I think, that the record of this Congress should contain some expression of the value of Mr. Hill's services in the cause of good roads, and that a committee be appointed to prepare a suitable resolution to be submitted to vote here this afternoon.

Chairman Lawrence then appointed the following Committee to prepare the resolution:

Chairman, Judge Hanford; and Messrs. E. L. Powers, of New York, and W. B. George, of Montana.

This committee met during the luncheon interval and formulated the resolution.

AFTERNOON SESSION, 2 O'CLOCK.

TARMAC ROADS.

The last session of the First Congress of American Road Builders was remarkable principally for the address of **Mr. E. Purnell Hooley,** of Nottingham, England, on the subject of "Tarmac Roads." Mr. Hooley's address was illustrated by several photographs of roads he had made and samples of the roads and material of which they were constructed.

Mr. Hooley, who was received with loud applause, spoke as follows:

PAPER BY E. PURNELL HOOLEY.

It is with considerable pride that I accept the kind invitation given to me by Mr. Hill to deliver a paper on a subject that has occupied in the past, and is occupying, the greater portion of every road engineer's best energies in England, as well as every other civilized country, viz., how to construct good and permanent roads at the minimum of present and future expense.

The only solution that the writer has been able to arrive at is the treatment of roads with tar as a binder, and this paper must be entitled "Tar and Its Uses in Modern Road Construction."

It is not here proposed to enter into any detail of general road construction. Other writers will deal, and doubtless have, as specialists in the many branches of the road question; but there is little doubt all will unite in agreeing that good roads are absolute necessities in the advancement and development of a progressive country, and that without good roads it is impossible to advance,

By roads, in this case, all roads, be it waterways, railways, horseways, are embraced; but for internal development and progress the ordinary highways must be the actual nerves that bring in touch the general internal public with the outside world.

In England the maintenance of highways has become of such importance that hardly a day passes without some new proposal being made for dealing with the cost of management of the same.

Broadly, at present, all the existing English main roads are vested in the county councils. The urban and rural councils have the care of the branch of district roads. New roads have to be made by private individuals, and have to be thoroughly well constructed and properly dedicated before they are taken over by the local public authorities.

This paper is to deal with ordinary country roads, not town streets.

The question now is, how best to repair the existing roads; and America has the experience of England to guide her in the matter of expense, and trouble, and very possibly can avoid defeat, by carrying out modern ideas in laying out and constructing new roads on the very best and up-to-date systems, rather than having to patch up and undo the failures and disasters that the ratepayers of England are so loudly grumbling about, in the present high rates they are called upon to pay.

Roads without proper foundations are the most expensive and disappointing to deal with, but to re-form the foundations of all the roads, 27,600 miles of main and possibly 92,300 miles of district roads, of England, say 120,000, would cost a sum so large that it is outside the bounds of possibility to even think of.

The general practice of all thinking road engineers now seems to be to treat the present roads as the foundations upon which to build roads of a permanent character.

In America it surely must be the only wise course to thoroughly construct new roads for the sake of present and future road users.

Leaving all questions of foundations to be dealt with by other writers, with the general proviso that all roads should or must have foundations, the writer will turn his remarks to surfacing.

Where roads have a first-class face, and it is possible to tar-wash that face at least once every four months at a cost of about 3 cents per square yard, tar as a surface binder will undoubtedly be a success in temporarily holding the surface of an ordinary macadam road together; but there its help and benefit ends. It will not make a weak road, subject to disintegration from below, a strong one. It will not hold material together when subject to disintegration from frost and thaw; for it certainly will not hold a road together in any part which mere surface treatment does not reach.

But a road composed throughout of thoroughly tarred material will do all that it has here been stated surface treatment only will not do.

Tarmacadam has been in use for many years in England, often it has been a success where least expected, and more often it has been a failure; and when a failure has to be faced, it is by far the best plan to go to the root of the trouble and endeavor to ascertain its cause, rather than attempt to continue the failure on the chance of success later.

The failure of Tarmacadam has been due to the inability to secure the adherence of the tar to the material that was to be tarred. The slightest moisture on the material or chilling of the tar means failure of adherence, and the use of a soft material that would allow of adherence means a failure through the road giving way as a whole.

No material can be used for the manufacture of Tarmacadam that is not hot or heated, and the more the material is heated, so as to allow the center of the material to be the hottest part, the better will be the tarring, but the weaker the material.

The materials that have previously proved the most satisfactory

in Tarmacadam work have been limestones from varying neighborhoods; but, if limestone has been subjected to a temperature sufficient to heat the stone throughout, the very nature will have been burnt or dried out of the stone, and the fact that tar is afterwards applied will not secure a road material that will stand anything but foot passenger traffic for any length of time. The difficulty also arises that, to heat sufficiently a large quantity of material, a drying and store place of such dimensions is necessitated as to make the cost almost prohibitive, apart from the large amount of manual labor required in so many times handling the material.

In the neighborhood of large iron works slag has been greatly, successfully, used as a road material, and when it was possible to convert that slag into Tarmacadam a fair result has from time to time been obtained.

Those who know anything of iron as made in England know of the large heaps of refuse slag which surround the big blast furnaces, and also know the disposal of the slag has long been a source of anxiety to the iron works owners.

While watching the slag pouring out of a furnace one day, it struck the author that the whole trouble of heating the slag for the manufacture of Tarmacadam was unnecessary; for here was the material that later would be in an ideal condition, ready and of such a nature that the very best results in road construction could be obtained.

He had a breaking and tar mixing plant constructed. The hot slag was brought from the furnaces in large caldrons, each containing about four tons, and allowed to stand for about twenty-four hours until consolidated. It was then tipped onto a cooling ground, and about twelve hours later, when the outside temperature of the slag was about 160° Fahr., broken up either by hand or by means of a dumping hammer, and conveyed, while the outside was still warm, to the breaker. It was then passed through breakers and screened to form varying gauges.

The center portion of the material, which was still the hottest, was passed into a steam-heated cylinder constructed to keep the material in motion; heated tar, pitch, and other compounds being poured into the same cylinder so as to form a perfect bath, and the whole turned and churned up. From the cylinder it was deposited into the railway trucks and was ready for use.

This material is delivered by rail where required, and can be produced at the works in a most remunerative manner for eight shillings and six pence, or say two dollars, per ton, to which, of course, must be added railway freights when conveyed to a distance.

The material is delivered onto the roads in the county of Nottinghamshire, with a railway journey of thirty miles, and up to three miles of road cartage, allowing for a thickness of three inches, when consolidated, of road crust, at a cost of from 60 to 70 cents per yard super.

This material has been in use for seven winters on a road with a water-logged, round-stone foundation, that previously had to be

coated with 2½ inches of Leicestershire syenite each year, and is now in good and perfect condition, with practically no surface dust, and absolutely no dust, as previously was the case, from attrition and disintegration. (Photographs Nos. 2 and 5.)

The scavenging is reduced to the removal of horse droppings and earth brought from the adjoining fields.

This material has been registered under the name of "Tarmac," to keep it from being confused with the old-fashioned Tarmacadam; and it is different from the latter, inasmuch as in its use the road surface is composed of a good wearing material 1½ inches in gauge, with a minimum of tar to waterproof it, and from its proper adherence, instead of, as previously was the case in Tarmacadam, being composed of very fine particles of softer stone, with a large amount of tar only partially adhering to it.

To construct a good Tarmac road, it is necessary to have an ordinary road as a bottom, or as good a foundation as is possible; if a waterproof one is desired, then it must be of Tarmac. The bottom layer of Tarmac can be of 4-inch gauge material, laid securely and rolled, with the interstices filled up with finer Tarmac, and the whole steam-rolled. The next layer should be about three-fourths of an inch in thickness, of ⅜-inch Tarmac, and left unrolled; on this should be supplied a 2¼-inch gauge Tarmac, rolled into the ⅜-inch, and, when rolled, ⅜-inch Tarmac would be swept with a brush into every crevice or open joint. Then a further layer of ⅜-inch Tarmac should be applied as before, unrolled, and, as a last coating, a perfect layer of 1½-inch Tarmac should be applied, and, after the roller has passed twice each way over its face, ⅜-inch Tarmac should again be swept into each crevice, so that a perfect face is presented. The whole must again be steam-rolled by a steam roller being passed over three or four times, and the road is at once fit for traffic. (See drawing of ideal Tarmac road, cross-section No. 1.)

If the traffic will not allow of the whole width of the road surface being stopped at one time, the work can be carried on by taking half the width at a time; but care must be shown in leaving each layer of material to form a Greek key lap.

It is bad work to attempt to feather the edges or thin down a Tarmac road. When a patch is applied, or a coating ended, it should be finished with a square or butt joint; if otherwise dealt with, the edges will fray or waste away.

The camber, or cross-fall, of a Tarmac road, should not be greater than 1 in 50 from the center to the sides, and a perfect formation should be carried throughout from the foundation, so that the whole thickness should be complete.

There is no need for pitched gutter courses in Tarmac roads, but in lieu a final washing of boiling tar to a width of 18 inches or 2 feet from the curbing to form a gutter prevents scouring and assists sweeping up in cities and populous places.

In the maintenance of ordinary macadam roads great difficulty is experienced in patching holes and depressions.

A most satisfactory patch can be carried out by means of Tarmac; and the practice is followed on all the main roads of Nottingham, either for ordinary wear in water-bound roads, or to repair disturbances in Tarmac roads.

It is necessary to cut out to the required depth any portion of the road surface that is loose, worn, thin, or disturbed, so as to leave a sharp, cleanly defined edge. This must be swept clean from any sign of dust in dry weather. Then a thin coat of ⅝-inch Tarmac should be applied with the greatest thickness at the edges. The necessary material for the patch filling is then applied, well and carefully rammed with a hand rammer, and, when rammed, any interstices filled with ⅝-inch Tarmac, rammed again, and when nearly dry the whole should be swept over with dust from the adjoining road surface. A perfectly level, neat patch is thus formed. (A better idea of this may be appreciated by a reference to drawing No. 2, and the beneficial result is clearly shown in photograph No. 3.) Here will be seen patches on the left hand, applied in the foregoing manner, and after twelve months' wear remaining good and strong as ever, very faint in outline, while the road adjoining is going to pieces in dry weather through heavy traffic and disintegration, though washed with tar.

Photographs are also presented showing (Nos. 1 and 4) a length of Tarmac road adjoining a level crossing immediately outside the town of Newark, Notts, and adjoining the Midland Railway Station. This road, previous to treatment in Tarmac in 1898, was annually repaired by the use of 2¼-inch guage water-bound Leicestershire syenite, the best available road stone of the neighborhood. When first laid the Tarmac cost two shillings four pence per yard super. This portion has once been refaced by the application of a 1¼-inch coat of Tarmac in 1905, and to-day is in perfect condition,

Photograph No. 5 shows the surface of a main road a mile and a half outside the city of Nottingham, population 300,000. The road is greatly used by farm carts, motors, and motor lorries, as well as ordinary vehicular traffic of all kinds. It has been laid four winters, and has had no other material applied to it. It is practically free from dust, and is absolutely an ideal road for all types of self-propelled and other traffic.

It is difficult to condense a subject such as this to the limits of an ordinary paper, and the best apologies are offered for the length that the paper has assumed.

If the hearers or readers are interested, and should any good result therefrom, the writer is well repaid, and, while frankly admitting that he does not state he has of necessity solved the road difficulty, he here lays the result of his labors before the great American people at their first Road Congress, and hopes the same will be appreciated and approved of.

Ladies and Gentlemen:

Here I finished my paper, but I could never forgive myself if I thus ended abruptly. I cannot—I dare not, for my conscience's

sake—say my public farewell to you without thanking you, one and all, for your kindness, your open-heartedness, your hospitality, and the right royal reception I have received in this your beautiful country.

The Great God has been bountiful to you in placing you all in such heavenly surroundings, and I am proud to feel, and see, that he has also given you men who, in their humble position as his instruments, are fully alive to their great responsibilities. I cannot name all these men—you know them better than I do—but I must name three.

I have never seen more beautifully constructed town roads, with such perfect faces, as those now perfected by Mr. Thomson. In this man you have an engineer that any city in England would be proud to employ, and could confidently trust their best interests to. Let me ask you to continue your trust, and let me by these few words show my appreciation of a great man.

In my opinion, in Mr. Lancaster you have a peerless teacher engaged in what we in England call real "spade work"—the most fruitful of all good work, for without it you cannot reap the good fruit hereafter. I have as an Englishman more than an appreciation of such a man and such work. His position is one I dare not undertake. The responsibility of it would be too great. But *he has undertaken it.* Remember this, and its responsibility, and be merciful, be kind, to him, and I beg you will help him; for he is helping others, and by that help helping you. The future generations will look back at his efforts, and I know will live to thank God for the kindly diffusion of his more than useful knowledge.

And now, ladies and gentlemen, let me finally conclude by paying my real respects to *the* man of all others that I feel you and I owe more to than any words of mine can ever express. You know whom I refer to—if he will allow me—may I call him my friend, Mr. Hill!

May I say Sam Hill? For as Sam Hill I firmly believe he loves you to think of him. Your and my friend—my host—Sam Hill! Look at him! To see him is to see he stands head and shoulders above his fellows, and to know him is to love him. Yes, love him, as real men and women should love their leaders; for is he not physically and morally a leader? I have never met such a man in my life, and I fear I never shall see his like again. He to me is peerless. He has no ax of his own to grind. His one object, that I have found, is for your and his country's good, and I know no man in this life more entitled to your and my respect and admiration. When the time comes, which must come to us all, for the Great Master to call my friend to his final rest, I feel the best epitaph that could be written on his earthly tomb would be:

"He Helped."

Ladies and gentlemen, I thank you again and again for all your kindness and patience, and say from the very bottom of my heart: Farewell. God be with you, in all your best endeavors.

Chairman Lawrence: I would like to suggest that a special vote of thanks should be tendered to **Mr. Hooley,** the great Englishman who has addressed us so very eloquently.

A rising vote of thanks was heartily tendered **Mr. Hooley,** who in reply said: "I cannot thank you more than saying: 'Thank you, thank you, thank you, from the bottom of my heart.' "

DISCUSSION.

Mr. Richardson: I have been greatly interested listening to Mr. Hooley, and would like to ask him what thickness of tarmac he puts on the top of his foundation.

Mr. Hooley: I do not like the term "foundation." I make the old road my foundation. That is the road, and what I have seen of your country roads I should be content to put it right on top of one of these roads. You want to put the three-eighths material; that is one thickness. On top of that you want to put the two and a quarter inch material that rolls down practically two inches. On top of that, when temporarily rolled, you want to put another layer of three-eighths to form a bed, and into that you want to steam-roll the one and a half, and when you have steam-rolled the one and a half you want to fill the interstices with fine material, and you get the finest piece of road. The "Denby" which we use is a light slag. If you break a piece, if you take a piece and break it, you will see that the inside shows a brown mark where the tar has got into the material, and that is what you want in Tarmacadam. Mr. Richardson took me since I came here to a piece of road, and we both smiled that anybody should be silly enough to make a Tarmacadam as we saw it. You cannot make it by putting dirt into tar. You want to make the material solid, that will stand your traffic, and not only wear, but allow the horses to stand on top of it. If you once get such a piece of good road, you will find any animal will stand on it in perfect comfort. In England we are a nation of grumblers, and to get over the possibility of anybody grumbling we make a strip of tarmac up the middle, and at the sides the ordinary macadam, and we have never made one but what the farmers have said: "What do you want to go and put mud on the road for. Give us a whole road of your tarmac." You may get

some idea of the traffic on our roads when I tell you that we have as many as six or seven traction engines, weighing from sixty to seventy tons each, passing over our roads in an hour.

An Inquirer: Can you use anything but slag? Can you use limestone, or that sort of stuff?

Mr. Hooley: Limestone, as we have it in England, is a failure. If you get an ordinary piece of stone, let us say ordinary granite, and you try to warm it, you can get the outside hot, but not the inside; for, if you do, you take the nature out of the stone. If you could make it warm right through, I would make tarmac at once; but if it is cold in the center, and hot outside, the tar gets away from it, and you get tar dust as bad as you can get it; but if you get it absorbed and thoroughly joined into it, you will have a perfect road, and I am only too thankful I have been able to use that refuse slag. If you had seen the letters which I have received, you would see that there is some good in a tarmac road made of slag.

Mr. Terrace: I am a farmer, and have been waiting anxiously to ask a question. We have heard a good deal in this Congress with regard to our streets, the making of our streets in the city, and the maintaining of the streets; but there has been very little said with regard to our country roads. You have been out to Orilla, and have gone over our improved highways. You have noticed the material that these highways are constructed of, and I want to ask you this question. In my opinion our present improved highways are a failure. We have got to get down and adopt something else, or this movement in this state is a failure. What I want to ask you as a farmer, with your great knowledge, I would like to have your opinion as to whether you think, with the present material we have at hand, and with your tar, that we can construct a road anywhere near as good as that road you have there (indicating sample road). It may cost more at first, but it certainly will be the cheapest at the finish, and we might just as well, as farmers, get right down to it and prepare ourselves to meet the cost. It is a business proposition, and it is only a mere bagatelle compared with the benefits we will get out of it.

Mr. Hooley: I should not like to say yes or no. I cannot make that road of granite or of trap. I cannot do it; but, when a man

like Mr. Hill tells me that he knows of a material which is warm and warmed through by your beautiful sunshine, directly he told me that, I said I could make tarmac, and he has promised to get me some for me to take home, and I have promised him that I would see the best use that can be made of it. My idea was to make something—may I say it—out of nothing, to make use of that which is waste. Before I got to Chicago, I saw you had a new town, the steel town, I think they call it, and they were beginning taking their slag from their works, and in that you have a material from which tarmac could be made. I am going to make the material with which Mr. Hill is to supply me as hot as I can by dipping it into the slag, and see if I cannot make the matter adhere to it, and Mr. Hill will be able to show you the result of what I have done with the material he sends me.

An Inquirer: Can you do it with water gas tar?

Mr. Hooley: No; you must have tar absolutely, and distilled tar. Water gas tar is too cheap and nasty for anything. The only thing to do with it is to get rid of it. In my experience, you must get good distilled tar, and with a proper mixture, not only tar, but rosin and cement, or you cannot make a proper road, and you must use a proper proportion of each; but, if I gave you the figures of how this is done, I would be doing what I had no right to do in my present position. I am not personally interested to the extent of five shillings in this matter; but men have ventured a great deal in this for my sake, and I must not give away the secrets which they do not wish me to. I may say that the mixture is tar, pitch, rosin, and cement; but, until you know the proportions, do not waste much money, and find yourself £500 or £600 out of pocket. You get a mixture which, when you see it, you will say: "It is the simplest thing. What a fool I was not to see it before." So was I.

I would like to get some of you gentlemen to come and run over some of my roads. I have five straight miles out of the city of Nottingham, and absolutely no dust or dirt on it. I am not going to say I can keep the dust off the road that comes from the fields. Mr. Hill, Mr. Lancaster, and Mr. Thomson have seen the road and traveled over it. You can go on the ordinary road by the side of it, and see the dust coming behind a motor in such thickness that

you cannot see the motor at all; but when you get on this road you will find a beautiful, smooth surface free from dust. It is a revelation, and we get motorists from all over England to come and run over this road. In Nottingham we have good roads, but this is the best. Any of you who have been to Brighton will know the Midway road, the invalid road, and this is the road they go up and down to avoid the dust nuisance. It was originally constructed for automobile speed races, and the records made on a public highway were made on that road.

Question: Could you tell us the cost?

Mr. Hooley: Something like from three to four shillings a yard; much further away than we are. Of course, there is the cost of taking it down from one side of England to the other; within the points which are close handy, the cost is not as much.

Question: What is the rate per ton per mile?

Mr. Hooley: It would be over eight shillings a ton to Brighton, because it is four shillings to London. To put the steam roller over the material requires no skilled labor. Any farmer can put it on as well as any of my workmen, if they follow what they are told to do. You can put the roller on in less than an hour afterwards without seeing any mark. I have a picture here of a park near Oxford, and the gentleman who took a fancy to my road said, "If you can make that for traffic, let me have it near my place," and I put it down at a cost of under two shillings a yard. I have also another picture here of a road at Aldershot which is dustless, so that the dust cannot worry the poor soldiers who are lying in the hospital. The total thickness of my road, when consolidated, is a little over three inches.

Question: Have you noticed whether or not, with the automobiles running over your road, whether the adhesiveness of the rubber tire takes out particles of the road material and causes a disintegration of the road?

Mr. Hooley: I can best answer this by asking if you remember the days when you were boys and played with the old sucker, and how you could lift up a stone by it and it would hold it up. The automobile is doing exactly the same thing with the road. It

sucks it out. Just at the point of contact the rubber is flat and you can hear it give. With my road you cannot get any sucking action out of it; but where you get a water-bound road, it has gone to pieces in less than a month, and yet some people are fools enough to keep throwing money into it and thinking they are making roads. If I were in the circumstances of the man who made that road, I should have felt I was doing very fair work if I carried out the general practice that was being carried out on that road; but I do not do it, because I know it is wrong, and I am thankful to say my county council have taken the same line. They say: "Why waste money? We do not want to pay rates for wasting money." They do not keep their county surveyors to look at.

Question: I would like to know whether tarmac can be made out of other materials than slag.

Mr. Hooley: I have not found any satisfactory results from anything but slag. Mr. Hill is going to send me the material, as I said, to see if I can make it out of that, and if I can I am going to send the result back. If it will stand, the tar will be as firm when it arrives here as when it leaves England. I might say the formula of our slag is 36.56 of silica, 16.40 of aluminum, 37.0 of lime.

Mr. Richardson: We have slags of the same type and composition through the Middle West, but not out here; but I may say I think we have great hopes that we can do out here with your asphalt on the Pacific Slope what Mr. Hooley has done with his tar, for the reason that we have bright sun here, which warms the rock through, and we have no difficulty in the East in getting adhesion.

The strong point seems to be in the foundation. He puts 3/8-inch material on, and then 2½, and this is forced by compression up into the other. The great difficulty you will find in this country is the great cost of the stone. The 3/8 material would be something extremely expensive in this country. Our crushers make plenty of 2½, 1½, and ¾; but we do not get the 3/8. But, as I say, I see great hopes for you gentlemen on the Pacific Coast to construct something of that type, using an asphalt cement for the purpose.

I wish to express my personal thanks to Mr. Hooley for what he has said. It has added much to my knowledge of the question

of construction of a waterproof pavement, and I have no doubt you have all appreciated it as thoroughly as I have.

Mr. Lancaster: As to the kind of asphaltic oil?

Mr. Richardson: The residual pitch; but you cannot get that to coat the stone, on account of its viscosity. Bring it down, by adding just as much oil as ordinary paving cement. The difficulty of heating stone artificially and coating it with tar is that the tar runs off the stone and the heat destroys the tar, because tar will not stand high temperature; but the asphalt has been heated to 700 degrees, and a little overheating does not damage it in the slightest degree.

A recess was then agreed upon, on motion of **Judge Hanford,** to give the delegates an opportunity of examining the sample sections of Mr. Hooley's roads and also the pictures of the roads which he had constructed.

After the recess **Prof. Lancaster** showed some stereopticon views of Mr. Hooley's road, which he, Mr. Hill, and Mr. Thomson had ridden over on their recent visit to England, after which the discussion was continued.

Mr. Richardson: Referring again to these roads, we have no slag here, and so we cannot use it. You must take your trap rock, which occurs all through the state, and you will have no difficulty in coating it with asphalt. You could not coat it with coal tar; but with the asphalt there is no danger of overheating. It has been submitted to 700 degrees in preparation, so a little extra heat can do no harm.

Question: How high would you heat it?

Mr. Richardson: To a temperature of 350 degrees without any damage; but you can heat it hotter. I think there is a great future in this part of the world for the construction of roads of Mr. Hooley's type with asphalt, putting the fine material first, and then the coarse, and then the fine material into the voids, and thus have a fine material from the top down. The only objection here is the cost involved. I was discussing with **Mr. Parker,** of Massachusetts, a few moments ago, and he said it was quite a difficult thing to get the three-eighths material at the bottom, and very expensive. The only way to arrive at the expense was to keep traffic data, to

see what it cost to carry a ton a mile, and the Massachusetts Highway Commission are accumulating these data. They are constructing a road from Gloucester, Massachusetts, on this plan with asphalt, so the state of Washington can learn from Massachusetts what there is to be learned in that direction.

Prof. Lancaster: Mr. Hooley's road is certainly the best we have seen, and the question that seems to trouble us all is the expense; but we do not want the people of the state of Washington to be discouraged if they were led to believe that only that kind of road can be made to stand.

Mr. Richardson: I could have brought you from New York a section of asphaltic macadam road, and you could have told from that; but the trouble is it is expensive. You want to avoid the necessity of having a plant for the heating and coating. We can do it under the summer sun in the East, and probably you could do it out here.

Mr. Parker: I do not know that it is safe for me to venture on any explanation of what we have been trying in Massachusetts at present. We have tried in the last few years something like two hundred different experiments with different kinds of tar and oil, and at the present time we are not satisfied with any one we have tried. We are quite sure we can reduce the number to a small figure, because of experiments we have made so many have failed. Mr. Lancaster has suggested that I should say something to you in regard to the Aitkin machine, the spraying machine invented in England, and used over there for some years, and which has been perfected until it has reached the machine which we are now having brought over. We have two in Massachusetts, which have been in use two or three months, and as I believe with very great success. We have found that we can use the heavy asphaltic oil in this machine quite as easily as any combination of tar.

Prof. Lancaster: I believe in the use of oil. The only thing I wanted to draw out of Mr. Richardson was his opinion regarding it. We have an abundance of oil at low cost, and could get seventy and possibly eighty per cent. asphaltic oil at the lowest cost.

Mr. Parker: Heavy asphaltic oil of that sort can be used on sand alone. At the Cape Cod region of Massachusetts, where the

roads are made up largely of sand, on account of the cost of the transportation of stone, and where it is largely a question of building roads which can be used during the summer months, the question of transportation by land was the most serious one that existed there. We tried nearly four years ago to use a heavy asphaltic oil mixed on the ground with pure sand of the Cape, and after some year or so of use, so that the sand by chemical and other action could mix together, a perfectly satisfactory sand road to drive over was the result. Of course, if that could be done, you would have the cheapest road it is possible to make, because for you here the heavy oil from California, which you can get at a dollar and a quarter or a dollar and a half a barrel, we have to pay from five to seven and a half cents a gallon for. We have tried the spraying machine on the surface of the road of the macadam roads in the following way: As it comes on the road, it feeds the tar into a spray, which distributes, according to the pressure applied, a gallon for from four to nine or ten cubic yards. The effect of this is that the tar is spread absolutely uniformly, and a very thin coat is very much more effective and beneficial to the roads, when applied under pressure, than the application of tar or oil in any other way, and the immediate distribution of the sand or gravel upon this surface, and rolled in or not, as the case may be, but preferably rolled in with a steam roller, produces a road which is absolutely satisfactory. The application of automobiles on this surface is to perhaps tear it up in places, and make it, therefore, unsatisfactory; but you overcome that by the continued application of this, so that when you have made two or three applications, and the sand has been absorbed by the oil or tar applied, you can get a thickness on the surface of the old road of two or three inches or more. The experiments we are engaged in making at the present time are as to whether it is possible to take out old, partially worn macadam roads, and restore them to a good, new surface that will stand the constant wear and tear of automobiles and other traffic. That is what we are in search of, and I do not hesitate to say I believe this is one of the remedies we are to find satisfactory and effective. You can easily see that oil put into one of these machines fitted in this way will distribute the oil in an absolutely even coat throughout. We have found the application of oil on a sand road, not mac-

adam, or hard, it is very difficult to get even, because by any means you apply it, by horse or otherwise, you destroy the even surface of the road, and the oil collects in the holes, which is bad for the road, not only making it uneven, but unsatisfactory in its final composition. The present state of our experiment with these Aitkin machines proves them to be the most promising machine we have had. I do not know that Mr. Hooley would agree with me. He has a different theory of construction, and has been very successful; but it is wholly outside of the practice of any of the ordinary conditions in the market.

Mr. R. H. Thomson: I would like to add a word or two to what Mr. Parker has said. We are no doubt all of us very much disappointed to find that Mr. Hooley hesitated to speak of any other system of road making than that which he himself has patented. There are in England several very successful systems of road making by the use of tar. We came from Paris to London and from London to Nottingham to examine Mr. Hooley's road, which, as has been said here, proved a wonderful surprise to us, and they were just as successful as the samples here would indicate. Mr. Hill, however, was not satisfied that that was the only kind of road that could be made. He said he had been round the world too long to believe that there was nothing but iron blast furnace slag that could be coated with asphalt or tar and made to adhere, so, while he left me in the North Country, he, with Mr. Lancaster, went to London to hunt up others. In a few days they called for me, and I went to London to continue the examination of the roads which they had discovered, and with which they were very well pleased. I spent two weeks in England, after they left, examining this matter, and as a result of that examination I am satisfied that what is known as the Gladwell system of road making in England is equally as effective, and perhaps more economical, than Mr. Hooley's, except where the slag is very easy to be had. In the Gladwell system the base is simply rolled down, being about four inches of ordinary macadam. Then the Aitkin machine, of which Mr. Parker has spoken, and of which there were photographs thrown on the wall, is run over the macadam, and it is sprayed with a very hot tar, which is cut with about three per cent. of linseed oil. This oil seems to cut the tar, and makes it very tough and viscous, making

it flow, covering a great deal more ground than it otherwise would, and being put on very thin with the linseed oil it has great adhesiveness. Then on top of that is put half an inch of good coarse sand, then the machine is run over the sand, and it is saturated with the same material, and then there is a top course of macadam laid on and rolled into this sand. Now this rolling gives a peculiarly smooth surface, from the fact that there is a mortar or bedding course of soft material between the bottom and the top. When the half inch of sand has been saturated, the top rock is laid on and rolled in, and the sand is driven into the crevices below and rises above, so that we have a top stone fastened by the asphalt or tar mortar to the lower stone, the mortar of tar doing service. Instead of being on top of the roadway, as many people try to put it, it is between the stones, and not worn by the surface of the wheels, and is slightly plastic, so that, if a stone is moved a little in ordinary weather, it will bed again, and the automobile appears to have no evil influence upon it. While I was in England the state of Washington ordered one of these machines, and it is now on the way, and I believe at present may be puttering along somewhere in Canada. Perhaps Mr. Campbell has got hold of it, because it was in his neighborhood the last time I heard of it on the way to Seattle.

Mr. Campbell: We will let you know how it works. (Laughter.)

Mr. Thomson: I also went to Birmingham, where they have laid many miles of roadway in the neighborhood of the city of Birmingham in this manner, and find it a very great success, and in a recent letter which I received from Mr. Stilgoe, the city engineer of Birmingham, he tells me they are making a number of miles of streets in Birmingham in this manner this year. They use Guernsey granite for the surface, and rock which they get in the neighborhood for the base. They simply put in from three-eighths to one-half inch of the saturated sand, and it binds the top and bottom together excellently; and Birmingham, which is a pretty thrifty community, is willing to spend a large sum of money for these roads. I also visited other cities in Central England, which are following the same course, and I have no question but that the stone which we have in the state of Washington, with the asphaltic oils which we have, can be bound together to make nearly, if not equal-

ly, as good a road as this of Brother Hooley. I do not want to discourage Mr. Hooley as to his road, but he is the father of the successful use of tar, and has the misfortune to believe that his children are the only good-looking ones in England; but we believe we will make as good roads as they do in England by the use of the machine which we have coming here, coating the under course, saturating the binder course of sand, and rolling the top course into it.

Mr. Parker: I would say, further, we have tried and are now trying such as you describe, by applying the tar out of this machine directly on the stones, with the sand on top, and another course on top, very much as you have already described it, only that the application of the tar is made by the machine, and not the ordinary method of application, and by the continued application you can get as much tar or oil as is considered necessary.

Mr. Thomson: What do you put on top?

Mr. Parker: We really do not use anything, except, perhaps, a little sand which has been treated with asphaltic oil to sweep into the crevices to prevent the clay sifting in. It takes very little to fill the crevices. I do not wish to take up your time, but what we have discovered I am anxious to let others know. It is necessary only in such cases as when your oil or tar will naturally by gravitation work towards the surface. As it comes up you cover it with sand, or often gravel or stone chips, and put on as much as the oil will absorb, because, when the oil or tar comes through enough to be unpleasant, all you have to do is to put some more on. That is the whole solution.

Question: Have you inspected the roads of Kentucky? We have macadam roads there.

Mr. Thomson: Yes; before you were born.

Question: I ask this, because they have recently made some very good roads there, and our construction now would certainly be different to what it was when you inspected it.

Prof. Lancaster: Some three years ago I saw the roads in Kentucky, and took some photographs of them, so I am familiar with what is being done. Talking about the machine which Mr. Parker is using in Massachusetts, and which we are going to have here:

We can put on such a small amount of oil or tar, and not get any excess on, but in an even way. The least anybody was able to get on the road heretofore has been four-tenths to half a gallon per square yard by the ordinary method. It would take half a gallon; using every care, and having the road clean and the material hot, and spreading the material on with brooms, it would take at least half a gallon to the square yard. The English have got the best results using one gallon to six square yards, so that you will see the great amount of saving of material by using the new machine.

Mr. Parker: The oil or tar applied, I find it is better that it be not distributed before you get the sand or gravel on

Prof. Lancaster: We thought we were going to get this machine to Washington first, and had arranged for it; but, when Sir Herbert Praed found the machine was coming to the A.-Y.-P., he said he wanted to build the best possible type, and he sent Mr. Parker our machine, and made another for us. (Laughter.)

Mr. Parker: Sir Herbert Praed told me that he was afraid to send the machine, because the Yankees would improve on his patents. He sent it to the Yankees, however, because he distrusted the shrewdness of you people here. (Another outburst of laughter.)

Mr. A. W. Campbell: With reference to the matter of using tar and asphaltum material for making roads does not remove the dust nuisance, which is about as important a question as has come before this conference. I have been exceedingly pleased with the papers here, and paid special attention to the way of treating these roads, and we have had the result of experience and investigation made by Mr. Thomson and others, and it looks as if we almost have to adopt something of this kind in connection with the streets of our towns and cities and the leading roads which are heavily traveled on coming into large centers. It has been a question in my mind as to whether we are going to be able to afford the extra expense of applying this on the leading rural roads outside of the city, and it necessarily adds considerable to the cost. The dust, however, appears to be almost unendurable, even on some of our best-constructed stone roads. I have seen them in our province and in the state of New York, where they have built some of the finest roads

on the continent of America. The dust nuisance seems to be almost intolerable, even when they have been experimenting with the use of tar and oil and asphalt. The automobile seems to contribute very much to this nuisance; but the investigations I have made prove that the automobile does not create the dust. The automobile simply raises the dust, which dust is created by the traffic —the hard tires upon the wheels. The broad, soft tire of the automobile will not wear the stone, but will pick up every particle that has been ground out of the worn stone; but the heavy loads upon the hard tires wear the stone into dust proportionate to the quality of the stone. If the stone is tough the wear is less, and if it is soft, of course, the wear is greater; but it is the hard iron tire coming into contact with the stone that creates the dust. The automobile passing over that road lifts the dust, and removes what otherwise might be a cushion between the hard tire and the stone; but the dust is created by the hard tire. I have seen many of our most excellent roads used extensively by heavy traffic from farm districts and it seems impossible for us to get an ordinary stone hard enough to resist the traffic, and it appears to me that one of our chief duties now is to study how best to minimize the creation of dust. We must use the softer stones to a very considerably extent until we have reached the time when tar, asphalt, and other such material can be adopted for the main roads generally; and I believe one way of minimizing the wear on the stone is, if possible, to increase the width of the hard tire of the wagon wheels. Reduce the cause of the dust, and we will have made one long step towards removing the dust nuisance. Some scheme by which we can induce the people to broaden the tires will reduce the wear. We make a road by using heavy rollers composed of broad wheels, and without that we could not properly construct a road. We can also maintain roads by carrying loads on broad tires resembling as near as possible the roller. Keep the road in repair, and remove the cause of the wear by increasing the width of the tire. I think that is one very important question for us to consider, and it will tend to reduce and minimize the creation of dust.

FENCES, HEDGEROWS, AND SHADE TREES.

This paper was read by **Mr. Harold Parker,** of Massachusetts, who in introducing the subject said:

I am afraid you are getting more than you expected. I was assigned this very interesting subject, and I wrote a short paper treating the subject generally. Since I came here, and have listened to your patient consideration of the matters that have been presented to you, and have noticed the interest which you appear to take in the construction and maintenance of roads, it seems to me you really ought not to be put to any further test. I think the paper ought to be laid on the table, and you should be allowed to go now, and if you say the word the paper shall be laid on the table, and we will close. (Cries of "Read it.")

Last winter I read a paper before the Governors of New England, and, the conditions of reading it being bad, it being in one of the theaters of Boston, and I not having read it after writing it, I had great difficulty in making it out, and it was declared in some of the press the next morning that I had not myself prepared the paper I read the day before. I should like to say I did prepare the paper, and also prepared this, and if there is any fault to be found it belongs to me alone. (Laughter.)

TREES, FENCES, AND HEDGEROWS.

By Harold Parker, Member American Society of Civil Engineers, Chairman Massachusetts Highway Commission.

In discussing the questions which are indicated in the title of this paper, it should be borne in mind that two causes for the results that have followed man's effort to beautify and improve what was first done from necessity alone must be taken into consideration, in order to bring before you the conclusion which I desire to make plain.

In the first place, before we can take into account the roadside trees, hedgerows, and fences, we must consider that the road itself was the first development of the necessities of man. He had to have a road which led from one point to another, not only for his own passage, but for that of the vehicle which carried his produce, or later contributed to his pleasure; so that, in the laying out of highways as means of transportation alone, neither the comfort of those using them nor the beauty of their surroundings was considered, the aim of the road builders being to secure the easiest means of getting from place to place.

It is not supposed to be a part of this discussion that I should consider the location, construction, or maintenance of roadways,

except in so far as the trees and roadside growths may be either a protection to the road itself or contribute to the comfort and happiness of those passing over it, which is, to be sure, a question of some economic advantage, and therefore has a value beyond the purely æsthetic.

Roads themselves have grown with the growth and wealth of population, and have usually kept pace with such growth, and, as the leisure and financial ability of communities increased, as well as the opportunities for improving their roadsides, the improvement of the roads and the beautification of the roadside surroundings became a sought-for consummation, and, as civilization increased, a practical interest.

In this way it may readily be seen that, where population has concentrated for economic reasons, there has gradually grown up the desire for æsthetic effects, as is shown in the creation of parks and public reservations for the enjoyment of the people at large.

For the same reasons the ornamentation of roadsides, extending gradually into the country from larger cities and towns, has developed and grown with the wealth of the people themselves; so that, as we look at it now in America, one of the considerations that is brought prominently to our attention, after building the best road that we know how, is the planting of roadside trees and other ornamental growths, and the erection of walls and fences that are no longer unsightly, but which will contribute to the beauty of the landscape and the unconscious advantage of those traveling over the road. This has now become so universally accepted that it cannot be ignored, even if those persons who are wholly practical consider it an unnecessary expenditure of money.

The development of this aspect has, of course, been different in Europe than in America, for there it has been so long and so gradual in its advance that it has attained in most of the civilized countries of Europe a finished result. There the roadside trees have been under intelligent care for generations, and produce on the mind of the traveler the most pleasing and salutary effect, even to those so ignorant that they cannot appreciate the reason therefor.

In France, and in other parts of the continent of Europe, like the people themselves, the results have been largely of a formal or artificial character. In England, nature has been followed more closely, so that you get two methods of beautifying public reservations and the space between the traveled way and the fields of abutting landowners, which have grown by degrees from primitive conditions to the present artistic state.

In America we have the advantage of both these methods worked out for our consideration, on which we can improve, but which do not give us immediately the results of trees of great size, or the finished appearance which comes through time alone.

To those of you who have driven horses or automobiles over the ancient highways of Europe, it must be painfully apparent that in comparison America suffers, notwithstanding the fact that in our older communities we have been striving for years to do in a

shorter time what has there required many generations of careful work and study.

In almost all of the larger cities of the East in America very large sums of money have been spent in the acquisition of land and the planting of trees and shrubs which will thrive in their respective localities, and in the careful treatment of roadside conditions for many years, and the results of these intelligent efforts have been to make such cities more attractive to visitors and more liveable to the inhabitants. It makes the conditions of life more healthful, and has a tendency to improve the people themselves.

The city of Boston, in Massachusetts, has expended over ten million dollars within the last twenty years in creating a park system for the use and at the expense of the metropolitan district, which, by the care that has been taken in its development, has become one of the most attractive and charming of any in the world; and this same theory has been adopted in many, if not all, of the larger cities, to a greater or less extent paid for out of the public purse; so that, as I intimated in the first of this paper, so great has the insistence of the public become, that in the treating of public ways or reservations the question of beauty, as it is manifested through the efforts of trained and skilful men, has become a practical necessity, and the public is entirely willing to take upon itself the cost, however great, of such work.

What is true of the parks and other public reservations is true, to a greater or less extent, of the roadsides themselves. It is the custom almost everywhere to plant trees along the sides of roads, wherever practicable, and to save the natural growth on a new road. Wherever the road itself is improved, it is noticeable that the landowners living along its borders instinctively improve the appearance of their possessions in proportion to the care that is expended upon the road and its immediate surroundings.

In Massachusetts, where the commonwealth builds and maintains its main lines of travel, and takes care of its roadsides, it is observed that farms and homes, previously deserted for years, are taken up, rebuilt, and beautified everywhere along the borders of the road. No deserted farms can be found along state highways in Massachusetts. This, in itself, is an argument sufficient for the expenditure of such additional sums as may be necessary for improving the roadsides, as well as the roadway.

The Highway Commission of Massachusetts is required, under the law, to plant useful and ornamental trees along the borders of highways which have been made state roads. In order to do this intelligently and with the best results, the Highway Commission has employed a trained forester, and it has also established a nursery, in which are cultivated trees and shrubs which are suited to all the climatic and physical conditions throughout the commonwealth. These trees are planted in locations suited to their character and kind, and are cared for under the direction of the forester, so as to attain their most complete and characteristic growth.

Where, in the course of the construction of state highways, it is necessary to make cuts through hills or embankments over low ground, it is the practice of the Commission to protect and beautify these cuts or fills by the planting of vines or shrubs which conceal their nakedness and prevent their disintegration. The work of the Commission along these lines has produced its effect upon the minds of those living along the roads, so that the ambition of the people to make their places more attractive, by the building of more or less ornamental fences, the removal of unsightly accumulations, and the general well-being of their homes, has been aroused, and the result is encouraging and satisfactory.

It is also to be considered that trees and shrubs planted along the roadsides protect and prolong the life of the roads, and the planting or preservation of low-growing shrubs or bushes prevents the action of winds in drying up and removing the surface of the roadway, which otherwise would lead to destruction.

It is very plain that, where roadways are shaded by trees, horses will draw greater loads for greater distances, and that, therefore, more may be accomplished than under other circumstances.

You will, of course, appreciate that in a paper such as this is it is impossible to enlarge upon the method of planting trees or other plants, how it should be done, or what kinds of trees should be used. Your conditions in Washington are so different from ours in the East that what would apply here would be wholly or largely inapplicable there.

It is usual with us, for example, to set out rock maples on the uplands which are exposed to severe winds or extreme climatic variations; white, red, or pin oaks on less exposed hillsides in gravelly soils; white, red, or pitch pines in sandy soils, unprotected from the sun's rays; elms on fertile bottom lands; and white maples and willows in swampy reaches. Chestnuts have not been used to any extent for planting, though they become with care very large and handsome trees. They are, however, protected when found growing naturally by the roadside. Other trees, such as poplar, ash, sycamore, locust, etc., are suited to certain locations, but are not planted by us to any very great extent.

A great variety of native shrubs, such as cornus dogwood, lilac, etc., are used to give a picturesque effect, or as wind breaks in exposed places. Such vines as blackberry, upland cranberry, low-growing sumach, etc., are planted on slopes and banks to protect them from disintegration, and to cover the raw appearance of new work. All these means can well be adopted to beautify and improve the sides of roads, and, from my experience, are well worth the outlay from any point of view.

DISCUSSION.

Mr. Samuel Hill: With reference to what Mr. Parker has said about abandoned farms, I believe, Mr. Parker, your Commission authorized me to state that in Massachusetts, where stone improved

highways had been placed, after careful investigation you found an increase on every 150-acre farm in the annual rental value of approximately $200. That is a startling statement, showing the increased value from improved highways.

Questioner: If there is one question more than another in this country and Canada, it is the fact of the people leaving the farm. I would like to know if the fact of the improving of the roads under the State Commission of Massachusetts has had the effect of bringing back to the soil those who had previously left it.

Mr. Parker: I would say in response to that question that the building of state roads and the improvement of the highways in Massachusetts has had the effect, not only of bringing back practical farmers, but to bring back to their old homes men who had been away and made a fortune in other businesses. I could name to you hundreds of such instances, and that where I have known deserted farms to exist as long as I can remember that now not one can be found on a state road. That is an economic question of value to you all, and should be considered.

An Inquirer: I would like to ask if the building of the highways has not decreased taxation greatly in comparison to real valuation. I mean that the improvements have so increased the valuation that they have lessened the taxes in proportion.

Mr. Parker: I think that is absolutely true, because in most cases the increase in the taxation is nothing, while the increase in valuation is very often double or trebled within my recollection by the building of these roads.

An Inquirer: Then virtually these roads do not cost a red cent?

Mr. Parker: We consider they do not cost a cent, but increase the value of the commonwealth materially every year. No movement that we have had in Massachusetts has been so popular as that of state roads, and I believe any amount of money that might be asked for would be given to the Commission without reservation. I mean by that that the commonwealth has an established principle of spending so much a year on state roads, and we as a rule do not believe in increasing that, but think we can spend from half a million to a million dollars a year more economically than a larger amount. However, whenever a special appropriation is

asked of the Legislature for a state road, I may say it has never been refused, and I may say that the Highway Commission of Massachusetts has now been in existence long enough to have trained its men thoroughly, and has received the confidence of the community to such an extent that, if towns and in many cases cities desire to spend money on highways, the money will be appropriated, but only under the condition that it is spent under the direction and with the approval of the Highway Commission. mention that as a comment on the result of this sort of work.

An Inquirer: Do you take charge of the parks?

Mr. Parker: No; not under our Highway Law.

An Inquirer: Is it not true that before you built those roads you had a bureau of abandoned farms?

Mr. Parker: I believe it was so.

Mr. F. N. Godfrey: I would like to say a little about the conditions in our state. The beautifying of the country roads in New York has added a great deal to the value of the farms. The farmer who plants trees in New York state is allowed a certain amount from his road tax. I believe it is 25 cents a tree, so that it has been an inducement to the people to plant trees. One word in regard to the statement that Mr. Parker has made in regard to his system. While Massachusetts is somewhat of a small state compared to New York, we have felt that it was wise to adopt their system of road making and road work in the appointment of a commission and the supervision of the roads by the commission.

PROFESSOR LANCASTER'S PAPER ON "BOULEVARDS" TO BE PRINTED.

In consequence of lack of time it was resolved that **Professor Lancaster's** paper on "Boulevards" should be printed in the Report without being read.

Mr. M. O. Eldredge: Mr. Thomson called attention to the Gladwell system of road building. We have in the Government Building a minature model showing exactly how the Gladwell road is built. We also have other roads showing methods of using tar in road building, showing tarmacadam etc.; in fact, we have all

the standard types of road construction, and I invite every one to come to the Government Building and make an inspection of these roads, and I will be glad to go with you.

Hon. C. H. Hanford: I would like to ask a question, with reference to the paper under discussion previous to the last, as to whether on our sea level, where there seems to be such a mixture of sand and pebbles, where a road could be made along the seashore, about the application of this tar by machine. For instance, between here and Tacoma, along the shore, could we get a roadbed by that system?

Mr. R. H. Thomson: You cannot make a roadbed with such uneven sizes as you refer to. Coarse sand would make a good road, but not with sand mixed with pebbles.

PRESENTATION TO MR. SAMUEL HILL.

Hon. C. H. Hanford: This forenoon this body voted to have in the records of this Congress an expression of appreciation of the very valuable services of Mr. Samuel Hill in advocating and working as he has in promoting the general welfare as affected by the public highways, and the committee appointed presents for adoption, if approved, the following resolutions. I would say that these resolutions, if adopted, are to be in the record of the Association as an expression of this body. Mr. Godfrey and Mr. Terrace, representing the Grangers and farmers, will have something by way of supplement to this report after I have read it:

RESOLUTIONS.

Resolved, by the First Congress of American Road Builders, that in Mr. Samuel Hill, President of the Washington State Good Roads Association, we recognize a leader whose wise, energetic, and constant efforts in promoting the common welfare as affected by the improvement of public highways command our highest admiration. Sparing neither time nor money, with voice and pen, Mr. Hill has given an impetus to a general movement for better roads in all the states of the American Union and the provinces of Canada, which must inevitably produce benefits important and lasting.

Resolved, that the thanks of this Congress are due to him, and are hereby expressed, for the many courteous attentions which Mr. Hill has bestowed, and which the members of this association will remember with keen appreciation.

Mr. Terrace and **Mr. Godfrey,** on behalf of the Association, then presented Mr. Hill with a handsome mounted cane amid loud applause.

Mr. Terrace said:

You are now going to receive proper treatment. We, farmers of the Pacific Coast, present you with this cane. May it stand in the rack for the next forty years. May you have no need to use it; but, every time you look upon this cane, may it encourage you to think that every farmer and his family look upon you as their great benefactor in the benefits of good roads. (Applause.)

Mr. F. N. Godfrey, of New York, said:

And, in behalf of the people of the Eastern part of this country, and especially the farmers and Grange of New York, I wish to express to you, in the giving of this beautiful token of respect from the delegates at this convention, their thanks and the thanks of the people of the East in what you have done towards the building up of this great industry and the furnishing to the people of the country a method of transportation which will aid the farmers in getting in closer touch with the people in the city. There should be no gulf between the country and the city (cheers), and I believe that the efforts you are making are a great step in this direction. I believe that the time will come when the country and the city will be one. (Cheers.)

Mr. Samuel Hill, who was received with loud applause and was visibly affected, said:

I am afraid I am going to have to use this cane before I sit down. It has been a good many years since I have seen a cane in the hands of the authorities, and I was somewhat embarrassed when they approached. I also remembered that perhaps my declining years attracted their attention, and they thought that something was necessary for my support. But there is something necessary for my support, and that is the cordial co-operation and sympathy of you all, and that I have had. It has been more than a duty, it has been a pleasure, to work in this movement. The first thought that I had when I began it was for the man that lived on the soil, and it has not been out of my mind since. If I should tell you the pleasure I have had in associating with men like Judge Hanford, Mr. Lancaster, Mr. Thomson, Mr. Landes, and others I could name, you would think everything was worth while to be with these men and to have their confidence. I told Mr. Parker and Mr. Hooley and the other distinguished men who have come here; in New York I told Mr. Godfrey, Mr. Richardson, and Mr. Powers of the character of the citizenship of this state—that, while we had great possibilities and great assets in the wealth of the state, the best thing

we had was in the character of the men that composed the citizenship of this state. I cannot turn in any direction but what I find men who have aided in this work. There are some men who have not done much talking, like Mr. Cheasty, Mr. Chamberlain, and a great many others; but I want to say to you all that the only reason we are going to have here in our own state the nucleus of a movement which is being nursed and developed all over the United States and all over Canada, our near neighbor, by the men who are here to-day and other men who sympathize but could not come, is because of the genius and spirit of the people on this continent, who do not wait always for governmental help or aid, but who try to help themselves; and when the State Commission gave us here this building for this purpose, and when the wise Board of Regents established in this University a chair of Highway Engineering, a step was taken forward. Once they tried to build roads by enforced labor; then they tried to build them for military purposes; but what the American people are trying to do to-day is to build roads on sentiment and for commercial reasons—to build roads so that they will help every part of the United States and Canada, all the people of both countries.

I cannot tell you how pleased I was that all these men laid aside their duties, and they are all busy men, and came here; how pleased I was that the Governor of every state and every province on this continent wrote letters and sent accredited delegates. It has, indeed, been a great pleasure, and the results of this convention, I think—I know—will be lasting.

I am very glad to be here. I am very much touched. (Loud applause.)

RESOLUTIONS.

It was moved, seconded, and unanimously carried: THAT a vote of thanks be tendered to the gentlemen who had made addresses and read able papers before the Convention.

It was moved by Mr. E. L. Powers, seconded, and unanimously carried: THAT the thanks of the delegates to the Washington State Commission be tendered for the courtesies extended to this Congress.

PERMANENT ORGANIZATION.

Mr. E. L. Powers:

It has been suggested that a permanent organization should be formed, and as the time is too short to consider the matter here at this meeting, I will offer a resolution that a committee of not less than nine be appointed by the chair to consider the matter of per-

manent organization and report some time between now and to-morrow before final adjournment.

Mr. F. N. Godfrey: I will second that.

Judge Hanford:

I think it would be difficult to make a comprehensive report as soon as to-morrow, and I would move, in amendment: THAT the committee be authorized to take suitable action to perfect permanent organization, and at its discretion to call a meeting of delegates from all the states and provinces represented here.

The mover and seconder of the motion accepted the amendment, which was accordingly put to the meeting and carried.

It was moved, seconded, and carried by a rising vote that Mr. Samuel Hill should be the president of the permanent organization.

The following committee on permanent organization was then appointed by the chair:

E. L. Powers, Chairman,
R. H. Thomson,
F. N. Godfrey,
A. W. Campbell,
Clifford Richardson,
Samuel Hill,
J. C. Lawrence,
A. N. Johnson,
Harold Parker.

Mr. W. B. George of Montana:

We have in our state the great National Park, and we appreciate the fact that men have come here to Seattle from all parts of the world, and that the state of Washington has set an example for all other Western states, and we want to come and visit you, and are ready to come. This question of the improvement of the roads is growing, and I think we should get the information which we have obtained here to the people. Every organization that is making machinery for roads, every automobile club, every member of Congress, and every one interested in the government of each state, every paper should be distributed throughout the country, and the people should become aware of the fact that this question of road improvement is the great enlightening question of this country, because it will make the farmer's land double and treble its present value. I have in a small way prepared a road which has caused the land to increase 400 per cent., and I will tell you that I appreciate the fact that the good roads will bring the boys from the farm into the church and school, and will develop the brains of the rising generation. I was talking to a lady to-day in Seattle, and she said: "The road question is a great question." Every farmer appreciates

that. We want to put into this thing the enthusiasm of our money. Let us make the coming Congress the greatest ever held. Look at irrigation. I want to say I secured this for Billings. We advertised six months ahead. We have got half a dozen stenographers and newspaper writers at work, and will make it as big as any Dry Congress held in the country.

Mr. Hill has been doing world-wide philanthropic work. He has been giving up something to make things better than when he came here. I want to leave the country I live in better than when I came into it. That is the spirit that is making the West. Progress is catching. A man cannot come and see them tearing down the hills and making roads, (for it is phenomenal what they are doing here) without being greatly impressed. I would not doubt to see a million people here in Seattle in a very short time.

Coming to this Congress has been an education in itself, and we want in some way to get this information before the people, educating the people in this, with a view to making it world-wide and interesting all in this great movement.

Professor Lancaster:

I know it is the intention of Mr. Hill to have the full proceedings, together with all papers, printed. There are a good many papers which have not been read, from the fact that we did not have the time, and these papers, many of them most excellent papers, will be printed along with the proceedings. I think it is Mr. Hill's intention to have each official delegate presented with a copy, and also to print other reports which can be had for practically the cost of printing. I think that is his purpose as nearly as I am able to inform you.

Convict Labor.

As Washington State has been referred to as utilizing convict labor, it would doubtless be interesting for you to know how it was brought about.

I think three years ago the subject was first broached, as I remember it, when it was spoken of at our state meeting at Yakima, and the committee retired and discussed the question as to whether or not it should be printed, because they feared, when it was spoken of, that the labor unions would oppose it; but we decided to press forward and present the question fairly to the people of the state, and it was mentioned often in our road meetings, and it was finally decided to take thirty men out of the penitentiary and carry them into a central part of the state. The men were selected at random, and we built a temporary stockade, and put the men in, and worked them without shackles. The men were worked in building a road where they used dynamite, blasting the rock and doing such work as hard labor would do. They saved the state a little more than $5,000 in building three-quarters of a mile of road, and the result was we took photographs of these men and used them before the Legislature, and secured from the Legislature

$124,000 for putting in four large rock crushing plants. Machinery for the four plants has been purchased, and we are using the best kind of engine, and when these four plants are in, as they will be, we will have the largest plant for supplying rock of any state in the Union, even ahead of what Illionis is doing, and crushing 1,500 cubic yards a day with prison labor.

PRINTING PROCEEDINGS.

Judge Hanford:

The subject of the publication and distribution of the record of this Congress is an important one, and should be treated in a practical way. I believe it is practicable to find ways and means of meeting the cost of publication, and, instead of having simply a copy for each delegate here, to have them printed in a way that they can be handled and get into the hands of the many people who will appreciate them.

I move that a committee of three be appointed by the chair on the publication of the reports of this Congress, to devise ways and means for meeting the cost, and to superintend the publication and distribution of the reports of the Congress, including the papers read and the discussions.

The motion was seconded and unanimously adopted, and the following committee was appointed by the chairman:

Samuel Hill, Chairman,
Hon. C. H. Hanford,
R. H. Thomson.

ADJOURNMENT.

The Congress then concluded their Seattle sessions, and on Wednesday night the delegates to the Good Roads Convention made a trip to Victoria, B. C., as the guests of Mr. Samuel Hill. Leaving Seattle about midnight, they reached Victoria in the early morning, and proceeded to the Empress Hotel, where luncheon was partaken of. Mr. Hill had made arrangements for a tally-ho ride round the city and through the parks; but Hon. Richard McBride, Premier of British Columbia, with his natural courtesy, insisted on providing automobiles for the entire party. After viewing the many beauties of Victoria, the return trip was made to Seattle at 4 o'clock in the afternoon; dinner being served on board.

The final business of the Congress was done on this trip; the most important feature being the appointment of a president, vice

president, and secretary of the permanent organization. It was unanimously resolved that Samuel Hill, Hon. James H. MacDonald, and E. L. Powers should be president, vice president, and secretary, respectively, and the committee of nine members which was appointed in Seattle was elected a permanent executive committee, of which Mr. Samuel Hill should be chairman.

It was also moved that President Hill should appoint a subcommittee of three to formulate a plan of permanent organization, to name the organization, and to draft a constitution and by-laws, to be submitted to the executive committee. This committee was nominated by the President as follows: E. L. Powers, of New York, Chairman; A. W. Campbell, of Toronto, Ontario; and J. N. Godfrey, of New York.

The following resolutions were unanimously adopted by the Congress.

THAT a vote of thanks be tendered to Premier McBride, of British Columbia, for the courtesies extended to the members of the Congress while in Victoria.

THAT a vote of thanks be tendered to the King County Good Roads Association for the courtesies extended to the delegates, and also to the press of Seattle for the way in which they reported and handled the Congress, and for the treatment which the delegates received at their hands.

The arrangement of the time and place at which the next meeting should be held was left in the hands of the Executive Committee.

The First Annual Congress of American Road Builders then adjourned after a most successful convention.

APPENDIX

[*The following Papers are here printed as a part of the foregoing Proceedings.*]

ORGANIZATION FOR CONSTRUCTION OF WAGON ROADS.

By Jno. F. Stevens.

Syllabus.

Organization—relation to the work.
Organization—for wagon roads, compared with railroad.
Organization—properly defined.
Relation of working force to finances.
Necessity for purely business methods.
Natural division of the work.
Difficulty of getting experienced men.
Necessity for best possible supervision.
Outline of a typical organization.
Necessity for strong executive head.
Characteristics such head should possess.
Roster of suggested organization.
Description of general duties of officers.
Great importance of proper care of laboring force.
Size and detail of organization to depend on amount and character of work.
Probability of Commission.
General remarks.

Organization for Construction.

Organization is the keynote which must be struck, to insure the successful execution of any construction project which involves the expenditure of a large sum of money, and is second to no other factor, even that of finance, in determining the final results. It is generally easier to provide money to cover the cost of a legitimate undertaking than it is to properly supervise its expenditure, and to be certain that none of it is wasted by careless and inefficient methods, or lost through intentional dishonesty. The stockholder, whether the state or a private individual, in communal or corporate association, has the legal and moral right to know that, as far as human skill can provide, the finished work, as turned over to him as its owner, represents every dollar which has been advanced by him, and is the same in total amount of property, simply trans-

muted into a different form, through the alchemy of brains and energy.

The organization of executive, supervising, and laboring forces to build wagon roads, especially in states or communities where no systematic efforts for such ends have ever existed, is, in some respects, more difficult of accomplishment than to create an organization for the construction of other large works, notably railroads. In the case of the latter, there is generally a parent company, a going concern, with its existing force of experienced engineers and technical, practical experts, which by expansion, modification, and some minor changes can readily be made into a trained, efficient machine, every component part of which is fitted for the particular duty to which it may be assigned; so that the too often costly contingency of "learning at the company's expense" is largely eliminated, and the work can proceed with economy and dispatch.

An organization, as commonly defined, is a plan which aims to bring into systematic connection and co-operation the separate parts of the whole. A *true* organization, in the sense of and for the purposes under discussion, covers wide ground, and possesses deep meaning. It means a machine, through the perfect operation of which the two great governing factors in the execution of work, *authority* and *responsibility,* can be defined and exactly located; for, without such efficiency, organization, as is too often the case, will be only an empty word.

In considering the creation of an organization suitable for handling the construction of state roads, it is fair to assume that the work is to be taken up *as* construction, and that the necessary financing has been done, and that the requisite funds will be in hand to meet current expenditures. In other words, the relation of the constructing forces to the financial part of the enterprise will be to supervise the expenditure of the funds and to properly account for the same. While the work of the financier and that of the engineer is generally considered to be entirely different in character, it is very true that they are closely allied, and that, as a matter of fact, each need and must have the intelligent co-operation of the other, to make a success of the work as a whole.

When a community, or a state, goes into the business of road making, it should place itself on exactly the same basis as a private firm or corporation undertaking similar work, if it expects economical results.

Every consideration, excepting the single one of strict business procedure, should be eliminated. Politics, temporary expedience, and local prejudice towards either sections or individuals should have no place in the organization or in the plans for the work. The only qualifications of the personnel of the force should be those of technical and business ability, coupled with strict integrity and honesty of purpose.

The actual work of road construction naturally divides itself into two parts—the purely technical, and the commercial or business. The former should be supervised and executed only by trained experts, naturally civil engineers; and this part is usually by far

the easier of the two. The locating of the lines of the road, governed, of course, by the controlling conditions in each case, the fixing of the standards, and the designing of the separate structures which go to make up the complete whole, is a comparatively simple matter, but one in which only trained judgment and experience should be employed.

The chief difficulty will be in finding men who have a practical knowledge of the other branch of the work. We have lagged so far behind in the matter of scientific road making, it is doubtful if in all the United States there are ten men who can truthfully be said to know in every detail how to build a piece of thoroughly first-class wagon road. This is a broad statement, and may be challenged; but it is the candid belief of the writer that it is not far from the truth. Our conception of what constitutes good roads is lamentably deficient. But no class of men on earth are more capable of intelligent expansion in ideas and knowledge than are our American civil engineers; so that, as conditions arise and crises develop, we can feel assured the right men will come forward to meet them.

The execution of the thousand and one details, every one of which should be under the eye of thoroughly competent business and executive superintendents, is a matter of all importance. It is not enough to know what a gang of laborers are receiving for a day's work, or that they are being employed the agreed hours. The party in direct charge must know personally, that their efforts are being intelligently put forth, that there is no lost motion, and that the state is getting as near 100 cents as possible for every dollar it is putting out, and this he can only know excepting as he has practical experience and possesses that rarest of all faculties, good common sense.

And this very careful supervision must run clear through from bottom to top, from the lowest gang foreman to the Chief Engineer or the supreme head. The complete whole will be no better or worse than have been the separate details, and it should be borne always in mind that no money is more wisely expended than for ample, intelligent supervision. And here is where officials of communities or states are liable to fall into error, through lack of experience and a possible feeling that ignorant adverse public criticism will follow. A railway company knows that to secure the best possible supervising talent, and to pay well for the same, is a wise policy. The state must recognize the same truth, and act accordingly, or results will not justify expenditures, and only disappointment will be the outcome. The days of miracles have passed, and it is not humanly possible that the conduct of a great and important work—one involving such a multiplicity of details, and on which the fierce light of criticism is sure to beat strongly—can be successfully carried out without throwing every safeguard around it that time and experience have proven to be necessary.

The amount, character, distribution, and general conditions will, of course, necessarily modify in size and detail the organization and methods best fitted to carry out any piece of construction work.

Still the same general principle should run through each, and the effort should be, as noted above, to locate authority and responsibility. Below the writer has outlined a skeleton organization, which may be contracted to cover a small undertaking, or expanded to almost any extent necessary to cover a very large one. The main points to be considered are simplicity and directness.

It is based on the theory that much, if not all, of the actual work of road construction will be done by what is generally called "day-labor"; that is, the state will deal directly, through its engineers and agents, with the actual laboring force, instead of committing the execution of the work to contractors, either by unit prices or by lump sum, either by mile, section, or as an entirety. Whether such a course is wisest does not enter into the particular phase of the question under consideration, and such question can only be decided in each individual case, when all the factors are fully developed and considered.

To premise: There should be a strong executive head, with power vested in it (or him) to plan, direct, and execute, to the extent of and under the law, all work, in general and detail, which is provided shall be done by such law, and its (or his) authority should be subordinate to no one, excepting the duly constituted executive head of the state. Whether this power be a Chief Engineer or a Commission is a debatable question. Personally the writer, from his experience, and perhaps somewhat from his training, believes in the one-man power, and that power the Chief Engineer.

Such a man should be big enough, in every sense of the word, to initiate and supervise, not only the technical features involved in the project, but also to ably direct the general business details; in other words, he should be, not only a capable road engineer, but also a first-class business man. He is the man who, more than all others, will be held responsible for results, and he should not be hampered by any attempted division of authority. There are such men, and they can be had by paying the price, and they are a good bargain.

A roster of the officers and agents of such an organization would appear about as follows:

- Chief Engineer,
- Chief Clerk,
- Accountant,
- Paymaster,
- Purchasing Agent,
- Draftsman,
- Principal Assistant Engineer,
  - Resident Engineer,
    - Assistant Engineer,
      - Instrument Men,
      - Inspectors,
      - General Foreman,
        - District Foremen,
          - Gang Foremen.

To explain: To the Chief Engineer, as the responsible head, would report directly: A Chief Clerk, who would have charge of all clerical matters, and who would be the right hand of the Chief Engineer, in all office and outside detailed matters not covered by other enumerated officials. All bills, pay rolls, vouchers, etc., originating on any part of the work, would pass through his hands before going to the Chief Engineer for his final action. He would be provided with such clerical help as from time to time might be found necessary.

The Accountant would examine and check, not only from a clerical, but also from a legal, point of view, all accounts, rolls, or vouchers calling for the disbursement of funds, and his approval would be necessary before any funds could be disbursed. He should have a thorough knowledge of the workings of the State Auditor's office, so that all construction accounts would be properly distributed, in order to harmonize them with the general features of the state's bookkeeping.

The duties of the Paymaster would be, as the title indicates: He should, either directly or through his subordinates, disburse all funds, but only on duly approved rolls, vouchers, or other proper form of indebtedness. He should, of course, as well as all his men handling cash or its equivalent, be under approved surety bond.

The Purchasing Agent would buy all material used in road making proper, also all commissary outfit or miscellaneous supplies needed in any department, and such purchases only be made upon regular requisitions duly approved by the proper officer, and such requisitions should, excepting in cases of extreme emergency, go through the Chief Engineer's office. He would also check, for amounts and prices, all bids and invoices up to the Chief Engineer.

The Draftsman would, under the supervision of the Chief Engineer, prepare all final maps and profiles, all standard plans of structures, and would, as far as practicable, be the custodian of all original notes of surveys, cross-sections, or other data relative to the engineering features of the work, indexing and classifying same in proper shape for ready reference, and also to turn over as a part of the state records, on the completion of the work.

The Principal Assistant Engineer would be the right-hand man of the Chief Engineer in all engineering and outside work, and should be second only to him in ability, experience, and capacity, and, as nearly as possible, should be qualified to act in place of the Chief Engineer, in case of the latter's absence or incapacity, from any cause. He should have direct and absolute authority over the Resident Engineers, and, through them, over all subordinate engineers and other assistants, down to the lowest Gang Foreman.

Practically all of his time should be spent in the field, directing, guiding, and advising, not only as to the general, but as to detailed, features of the work, whenever and wherever such assistance might be needed. He should be provided with ample and proper means for transportation, to enable him to quickly and thoroughly keep himself in constant touch with every part of the work, and thus, by

his knowledge and experience, guide the subordinate engineers, who necessarily would be younger and less experienced men, through the many and oft-recurring perplexing problems, which will continually arise. The value of such a man is inestimable, and the moral effect upon the successful progress of the work which such an official can produce, as the direct impersonation of the Chief Engineer, is incalculable.

The work, when organized for construction, should be divided into sections, of a varying number of miles, according to its character and importance, over each of which should be placed an Assistant Engineer, provided with the necessary Instrument Men, Inspectors, etc., to enable him at all times to not only give the necessary lines and levels to direct the foreman, but also to keep in close touch with every detail as it is being carried out. The General Foreman should report directly to the Assistant Engineer, and should, of course, have charge of the Gang Foremen. As a rule, the sections should be of such minimum lengths that the Assistant Engineer can personally visit all parts of each at least every other day.

When the work is of sufficient magnitude, or is so scattered as to make the visits of the Principal Assistant Engineer somewhat infrequent, a Resident Engineer, having authority and jurisdiction over several Assistant Engineers, can be profitably employed, thus condensing to a reasonable extent the necessarily detailed work of the Principal Assistant, and enabling the latter to devote the requisite time to the more important matters. Any of the above-enumerated officers, whose work calls for such assistance, should be provided with proper clerical force to enable them to keep up with their current work from day to day and to make correct returns at the stated periods of all reports, time sheets, pay rolls, invoices, property accounts, etc.

One important feature, in carrying out any construction project, is the housing and care of the laboring force. The right of the laborers to comfortable quarters and proper food is unquestionable; but, while admitting this moral and legal view of the case, there is a very practical side to it also. There is a homely and true saying that an "army moves on its belly"—meaning, of course, that the efficiency of a fighting force is proportionate to its commissariat. You have got to feed and sleep a man properly, if you expect the full measure of his services, whether mental or physical. Excepting on large jobs, the Principal Assistant Engineer, by the nature of his duties, taking him constantly over the work, can, with the assistance of some Inspectors, attend to this too often neglected branch of the service. But in the case of extensive construction a commissary official, reporting probably to the Chief Engineer, through the latter's Chief Clerk, to attend to the establishing of camps, the hiring and overseeing of all stewards, cooks, etc., as well as exercising supervision over the character, distribution, preparation, etc., of all food and camp supplies, will be found both useful and economical.

Now the writer foresees the criticism which will follow the suggestions of an organization as outlined above, as of its being too elaborate and expensive, etc. In the first place, as he has expressly said, it can be enlarged or contracted to fit the size of the project; and, in the second place, attention is specifically called to the absolute necessity for ample supervision, a point which it is desired to emphasize particularly. No surer way can be found to waste money at the bunghole than to try to save at the spigot of insufficient oversight by intelligent men of every class and at every stage of the work.

On small works the Chief Engineer could probably dispense with a Principal Assistant; the Chief Clerk, or his men, could act as Paymaster or Purchasing Agent, or both; and, similarly, other consolidations could be made. So, also, in case any considerable part of the work is carried out by contract, many of the lower officials, such as general and gang foremen, timekeepers, etc., would become a part of the contractor's staff, and not of the Chief Engineer's. But the general principle of localization of authority and responsibility should never be lost sight of, as it is the one and all-important feature of a successful organization.

Reverting to the necessity of an all-powerful executive head: It is quite probable that, for reasons which seem good, the general power to direct the construction of state roads may be vested in a duly authorized Commission. Then, in such case, the necessity for a competent Chief Engineer is none the less great, only he should report to the Chairman of such Commission, instead of directly to the executive head of the state. But he should be given full and complete authority over all matters of construction, and the Commission should confine its energies to carrying out the general provisions of the law, and not to attempt to interfere with or direct the affairs, which can only be properly handled by the one man, whose word and decision in all construction matters should be regarded as final, and from whose decision there should be no appeal, excepting to the law.

The genius for developing efficient organization is largely inherent in some men, and it is very surprising how simple the most complex construction problem becomes in their hands, and how smoothly and quietly the machine moves along, when it has been designed and built under the watchful eye of the master mind. And its efficiency and consequent value is shown no more forcibly than by the perfect fitting of each separate part—each officer and employé knowing that to him is given certain authority and that from him will be expected certain results. This knowledge, combined with the fact—which should be ever kept before his mind—that in all matters under his jurisdiction, he is at liberty to, in fact that it is his duty to, suggest improvement in methods of conducting affairs, and that he will receive proper credit for such suggestions, will not only keep the machine running to its full efficiency, but will improve its working, until it becomes well-nigh perfect. And in no other way, excepting through the workings of a system-

atic and well-balanced organization, officered by men carefully chosen only with regard to their fitness, can the state be assured of that success which is its due, and which it can justly claim, providing it recognizes that road making is a business matter and acts accordingly.

SUBGRADE PREPARATION.

By James H. MacDonald, State Highway Commissioner of Connecticut.

A well-built road's chief characteristic is not unlike a well-constructed house, at least in one respect. Both will have a similarity, namely, a tight roof and a dry cellar.

The different conditions to be found throughout the United States have made it imperative to vary the treatment or method employed in the construction of roads. This is true, not only in regard to climatic conditions, where they vary and change many times within a few hundred miles, but it is essentially true in regard to the different materials with which to construct roads in each state. The geological formation, topography, and other conditions force the adoption of widely different materials to be employed in the several states. Each, in turn, performs its own useful function, and all are made to satisfy that which is required of them, be it oil, stone, gravel, sand, limestone, asphalt, or cement for the surface of the road. But, no matter of what material the road shall be constructed of or with, there must be certain rules adhered to and treatment closely followed, without any deviation in so far as that which is necessary to furnish a proper foundation upon which to place that which is to furnish the wearing surface to the road is concerned.

The utilization of the different materials to be found throughout the country is one of the most profound questions of the hour. The brightest minds of this country are being trained to develop to its greatest field of usefulness that material which will lend itself a willing and obedient servant to the master road builder's hand to accomplish that which is required of it.

No matter how much taste is displayed by the architect in the outline or the appointments of your home, no matter how expensive the material used in the construction, no matter what taste is displayed by the owner in regard to the exterior or interior of the building, if the house is not constructed on a proper foundation, all of the work of science, and of art, refined taste, and money, is wasted. So that the subject-matter I am to treat to-day, in my judgment, carries the most essential and important feature in the whole science of road building.

A well-built road must have the ability to sustain and hold up into the position it should occupy the wearing surface of the road, whether it be two inches or two feet in depth. Any yielding of the subgrade will be fatal to the road. The whole question of dust-laying and road-preservative requirements of the hour is simply relegated to a secondary position, when compared with this very important feature of the construction, and the remarkable aspect of this important part of road building is that it is not so much the expense, for the same principle can be adopted in the simple turn-

piking of a road as that which will have to be employed in the most expensive construction that we are called upon to build to-day.

In dealing with the different materials that we encounter in the improvement of a section of road, the old saying is still true that the greatest accomplishment a human mind can achieve, as we have been told by one of the wise men of other days, is to "Know thyself," and to take the material we have had for thousands of years in that particular section you and I are familiar with and have walked or ridden over ever since we can remember, and, by a scientific treatment of that material, bring to each a devolopment that will accomplish that which will utilize the material to the best advantage. That is high art, indeed.

The first principle to follow in every case is to properly drain the section of road to be improved, after which you then take up the question of subgrade, or foundation, upon which to build your road. I have found the best material with which to construct a subgrade is sand or gravel. Disintegrated rock, with an admixture of light loam, makes a capital subgrade. I have known cotton cloth or unbleached muslin to be used on the surface of a sand subgrade. These roads have been called calico roads; but this practice has been abandoned, and a better process has been resorted to.

Sprinkling the sand before rolling, using a light roller before using the steam roller, or lightening the roller by relieving the boiler of one-half its water capacity, is a great assistance in firming the road, as the sand will not then creep before the roller, thus making the subgrade firm. A little subsoil placed on top of the sand is a very good practice. This will prevent the material from being pushed ahead of the roller, and it will make a good sustainment for the stone or gravel. If something is not done to make a sandy foundation firm, it will shift.

Slighting the subgrade is sometimes practiced by contractors, with the result that they do not gain anything, by reason of the fact that the contractor has to pay in the end an increased expense, owing to the fact that there will be a greater shrinkage in the stone. The wise contractor is the man who will spend more time with his fifteen cents an hour help in forming the subgrade, and thereby require less stone or gravel and other incidental expenses. This is often the reason why the tonnage of stone per mile has been largely exceeded over the original estimate of the contractor. This is very easily demonstrated by taking the cost of the stone per ton, with freight, the haul from the cars, the time consumed in applying the stone on the road, to say nothing about the expense of watering and rolling required to get the road into a perfect bond—firm and unyielding.

But you will ask, naturally, "Is not the road better by reason of the fact that more stone has been used?" Not at all. This would be true if a uniform depth of stone were on the road. But it is an intermittent depth. In some places there may be four inches of stone, while in other places there may be eight inches. The influence of the roller is not uniform where the subgrade is not suffi-

ciently hard and firm. Wherever there is an intermittent depth of stone, the road will develop a weakness, because the pressure of the roller on the road has not been uniform.

A road, in many respects, is similar to a house. If you are building a house, you must have, not only a good foundation for the house to rest upon, but you must also have a tight roof. And, in addition, you must have a dry cellar. If you have a tight roof, and do not have a dry cellar, of what earthly use is it to keep the water from the outside from getting in, if you have a leaky cellar that will let it in below? It is the same in building a road. You must have a good, well-built, substantial foundation, as well as a good surface—a roof—to your road. Not enough attention has been paid to this question heretofore. Commissioners, and others officially employed, have not always been to blame, however, as the power behind has brought up the dollar sign, and, to keep peace in the family, judgment was set aside and conscience was quieted with the hope that it might come out all right—a fond, foolish illusion, never realized. I do not believe, and never have believed, that the surface of the road can ever become an accomplished fact until this all-important and necessary adjunct to a good road—the foundation—is taken care of.

Antedating the surface must come directness to your road; then, the reduction of the grades to a minimum; then, the question of drainage. Of all these, the most important is under and surface drainage, after which comes the question of surfacing—the least important of all things connected with road building. You want directness to your road, to shorten the distance and minimize the danger, and to carry the surface water to its nearest and best exit point. It is not enough to get the water off and out from the road, but it must be gotten away from the road. When we have done this, we can commence to properly construct the subgrade, and not before.

Next comes the veneer, or surface, be it of macadam, gravel, disintegrated rock, or subsoil. How many miles of splendid looking macadam, gravel, and earth roads have, after two or three years' travel, broken down and gone into disrepair through a lack of knowledge, carelessness, or neglect to properly treat the subgrade?

You may say: "That is all very well, Commissioner; but suppose there are developments in the cuts that were not expected. What then?"

Suppose there is, and it is fair to assume, in the light of my own and other Commissioners' experience, that such will be the case, and that we find conditions very similar in many improvements where unexpected developments occur.

A very simple precautionary clause in the specifications will meet any of these unexpected conditions, by simply stating in the specifications that if, in the process of grading, the contractor finds any material that will be liable to heave, yield, or settle, he shall remove it and furnish that material which will be competent to sustain the stone or gravel and the travel the surface will be called upon to

bear; also put in a clause for bids for rubble drain and for Telford work by the linear foot, or yard. These bids will then fortify you against any developments, so that you will not be at the mercy of the contractor. In my state specifications I call for bids for many things that may not develop, and at the time of asking for the bids I do not anticipate being called upon to employ them in the construction of the work. It is better, I find, to lock the stable before the horse is stolen, rather than afterward.

I may seem to have taken considerable time in the development of this question of subgrade; but it is so inseparably interwoven with other essentials that, in taking up the question, I was unable to do so specifically, for it is really the link in the chain of the whole science of road building, and a chain is no stronger than its weakest link, no matter how well built that chain may be.

As a general proposition, in accomplishing a well-built subgrade, it is always well to remove all loam, roots, and vegetable matter from the proposed travel part of the road, also everything of a springy nature, or anything found in excavating for said roadway that will be liable to heave or settle, and fill all such places with clean sand or gravel.

Where it is necessary to fill to bring the subgrade up to the height required, I have found in my practice, where the filling exceeds one foot in depth, that the filling should be deposited in courses not to exceed twelve inches in depth, loose measurement, and require that each course shall be extended across the entire fill and completed before commencing another course, no matter if the fill be two or twenty feet. And this method should be followed with each succeeding course until the established grade is reached. The constant traveling over each of the courses by the teams employed in handling the material will remove the possibility of ever having a cracked fill, or one that will slide after the road has been constructed. This is a very important matter, I find, and I have used it in my work in my own state. I also find that in the cuts it is well not to plow down below that point that is to be the finished grade of the subgrade, but to keep it a sufficient height above that, so that when the roller is placed on the work it will make a good solid foundation, and you will not have to resort to filling in the cut to bring the subgrade up to the grade desired. These two principles of cut and fill will be found to work to great advantage in the proper construction of a road.

The shape, or contour, of the subgrade has been somewhat a matter of controversy; some engineers holding to the level line foundation, and putting on an extra depth of stone, or material, in the center to make the contour, or shed from the center line of the road to the berms, or shoulders, while other engineers have given the subgrade, or foundation upon which the wearing material is to be placed, the same contour as the finished road. I have used this latter method in my own work in my state, by reason of the fact I believe it makes a better foundation, and that the uniform depth of stone at the shoulders will assist in holding the crown of the

road in shape and furnish a sustainment at the shoulder line better than to have a less depth of stone at the shoulders and a greater depth at the center of the road. It also assists in case of a breaking up of the road, or a fracture, or other developments, in draining to the side, or shoulder, of the road.

The forming of the shoulders is a very important matter. They are really the support to the road. It has always been my practice, when making a shoulder in the fills, to lay out my road and put the newly added material ten or twelve inches into the new travel path, tamping it down firmly, and then cutting back to the line, thereby making a good, firm shoulder to work to, and to hold in place the stone or gravel in the travel path of the road.

It is a difficult matter to treat this question as intelligently through the medium of the written word as it would be with charts, which it had been my intention to use, had I come in person to the convention; but, if these principles are followed in building the subgrade, a good foundation upon which to put the wearing surface will result.

Where a weak foundation—a springy nature of the soil—occurs, the material I have described to be used for the subgrade would be replaced by a good Telford construction, namely, a stone base; but, inasmuch as I am not taking up the general proposition of materials and how to use them above the foundation, I will not enter into that particular phase of the road building question.

There are many features about road building that the people of our country are unfamiliar with, and even those who are in authority, and are actively engaged in this work, and are professionally employed in making this great question of scientific road building their life study, are as yet students in regard to this matter. But, notwithstanding this statement is an acknowledged fact, the progress made during the last sixteen years in the science of road building has been marvelous, and the most remarkable feature in the progress of this movement on the part of our country is that, while our people have been wedded to old customs and practices in road building, they are fast coming to acknowledge the fact that there is an art and science in the proper construction of a road, no matter what the material may be of which a road is constructed. The development in the interest of our people during the last six years emphasizes this fact in no uncertain way.

I am very glad at this time and in this way to contribute these few suggestions, hoping and trusting that something that I have said may be the means of doing some good.

I also take this opportunity, as I close this little article on subgrade treatment, to extend my hearty congratulations to the people of the Far West and to the many friends I met on my visit to the Pacific Coast nearly two years ago. I hope and trust the convention will result in renewed activity and a greater interest and an increased knowledge in this great work we are engaged in, and which means so much to the people of our entire country.

ROAD MATERIALS AND SOME SIMPLE RULES FOR TESTING THEM.

By Austin B. Fletcher, M. Am. Soc. C. E., Secretary Massachusetts Highway Commission.

A great diversity of materials enter into the construction of roads of the present day, for in this great country of ours every variety of climatic, geologic, and topographic conditions exist. Materials which might be economically useful in one part of the country may not be used elsewhere with economy because of excessive costs of haulage. An inferior material may often be useful economically because of the great cost of securing a superior material, and in general, without reference to city streets, which do not come within the purview of this paper, it may be stated that for our common roads we must rely upon materials which are native to our own locality.

This is true when the United States are considered as a whole, and it is equally true when the needs of any single state or locality are investigated. Even in so small a state as Massachusetts, with its area of only 8,200 square miles, it often happens that an inferior local stone must be used, because it is better economy to reconstruct or resurface more frequently than to pay the cost of transporting the much superior trap rock and with it resurface less often.

Indeed, it sometimes happens that it is better economy to use a gravel which admittedly requires attention at relatively short intervals of time than to use local stone in the form of macadam. And in some of the Middle States and elsewhere it is found that, by the skillful use of the log drag, ordinary loam makes a very good road surface during the greater part of the year.

There is, however, an exception to the general statement made above. In many of the states where asphaltic oils are not indigenous it seems possible to produce very fair results by combining such oils with sand and gravel. Reports indicate that much work of this sort has been done in California during a period of some years. By reason principally of the relatively small quantity of the material which is required, it is possible to transport the oil for long distances economically. Massachusetts, geographically, is as unfavorably placed as possible as concerns this material; but the long haul from the Middle West or from Texas does not seem to preclude its use.

The writer has tried to make it clear that a general discussion of all of the materials used for road purposes in the United States is difficult, at least from the personal knowledge of an individual, and therefore this paper is limited to such materials as he is familiar with and which are commonly used in Massachusetts. He does not pretend to any acquaintance with gumbo, novaculite, as-

phaltic rock, etc., which are without doubt very useful materials in the localities where they are found.

The paper may therefore be divided into the following parts:

1. Sand and Clay.
2. Gravel.
3. Rock Suitable for Macadam Purposes.
4. Bituminous Materials.

In what follows it should be remembered that the writer is discussing materials for use on roads having at least a moderate amount of traffic. Some statements do not apply to by-roads, or ways upon which the traffic is small, and in general main intertown roads are referred to.

Sand and Clay.

With the single exception of ordinary earth or loam, sand and clay in combination is probably the lowest type of material available for road purposes.

Without doubt loam should never be so used, with regard to economy, if anything better is obtainable at a reasonable cost. It is true that by the use of a log drag or road scraper, under the direction of trained operators, loam roads may be kept in excellent condition during the summer months; but in the spring, with the frost coming out and the snow melting, the condition of such roads is intolerable.

Sand, of itself, while at its best in winter and spring, does not ever have sufficient stability to sustain traffic over it; and clay, of itself, is open to the same or greater objection than loam.

It is possible, however, to combine sand with clay in such a manner that under moderate traffic and favorable climatic conditions a fairly serviceable road may be obtained. But, were a gravel even of inferior quality available, a sand-clay road would not be considered seriously.

Gravel.

Gravel, unlike sand, loam, and clay, is not a simple material. Indeed, it is usually a mixture of materials—small pebbles, or stone fragments, combined with either sand or clay.

It is very widely distributed throughout the glaciated portion of the country. Professor N. S. Shaler has stated that it rarely occurs that gravel cannot be found within any area of ten miles square in the glaciated field.

But gravel suitable for road purposes is not so plentiful as the foregoing statement would indicate, since, unless the pebbles are combined with the sand or with the clay in proper proportions, the gravel, without treatment, may be of little value.

Probably the best gravel is what is called in some parts of New England "blue gravel." This material is in effect finely broken trap rock, which has been subjected to little or no water action. The fragments are angular, the gravel contains little argillaceous

matter, and when placed on the road and rolled the fragments lock together into a mass having relatively few voids and great stability. The deposits of this blue gravel are rare, and the community with a bed of such material is to be congratulated. Its road problem is not a serious one.

As between the sandy gravels and the clayey, the choice should be usually in favor of the former, unless the clay is in relatively small proportion. Too much clay makes a muddy road, and one which is easily rutted by traffic. Too much sand, with large pebbles, makes a mass with little or no stability, and no amount of rolling will compact it.

For the best results, in general, considering the ordinary gravels, the writer believes that all stones which will not pass through a two and one-half inch mesh should be screened out; that at least 50 per cent. by weight should consist of pebbles or fragments which will not pass through a one and one-quarter inch mesh; at least 80 per cent. should not pass through a one-half inch mesh; and that the remainder should consist of small fragments of pebbles and sand from less than one-half of an inch in diameter to an impalpable powder.

The writer admits that such a gravel is too rarely found; but he offers it as an ideal, to be approached as nearly as is possible, always bearing in mind the economics of the problem.

A gravel so graded, when properly rolled, has great stability in the road. If the pebbles in the gravels are from rocks of a crystalline or eruptive nature, as is usually the case in New England, a road built of such material will make but little mud under traffic, and should not rut to any considerable extent, even when the frost is coming out of the ground.

Rocks.

In general, the chief desiderata in rocks for road building are hardness and toughness, and the writer believes that toughness should be written first. It is wholly within the range of possibility that in the most modern types of road surfaces, considered economical for the kind of roads herein contemplated, namely, those in which some form of bitumen is used as a binder or matrix, or as a wearing coat, stones of somewhat inferior quality may be used safely.

If the road builder has a choice between stones for macadam purposes, and too often he has not, no scientific instruments of precision are usually required to determine the relative value of the stones. The stone hammer and the scratching of one stone with the other are all that are necesssary. And it may also be generally stated that the rocks having a fine texture are more likely to be tough than those having coarse crystals. When there is not an excess of motor vehicles in the locality, a smooth-surfaced road will be more often secured if ledge rock is used, rather than field boulders. The field stones are usually of glacial origin. The fact that they escaped utter demolition in the cataclysmic grindings of the

glacial period indicates that they were of the toughest and hardest parts of the rocks from which they were separated. But, while they may be harder and tougher than the ledge rock in the locality, because of lack of uniformity in these characteristics, comparing boulder with boulder, the road surface in which they are placed is likely to wear less smoothly than if ledge rock is used.

Under very light traffic, or when motor vehicles predominate, the writer believes that a relatively soft rock will often prove to be more economical than a relatively hard one; also that under such conditions, when a good gravel is obtainable, its use will usually prove to be more economical than if the road is built after the macadam type.

Much has been said and written about the cementing power of the fine dust or powder which results from the crushing of stone by machinery. The writer believes that certain stones, notably the limestones, undoubtedly produce screenings of value in this respect. But, while most of the other stones make a dust almost wholly lacking in this property, such screenings, when properly applied, serve well as a binder. It would seem that the action is more mechanical than chemical. The fact that sand, if the particles are angular and not rounded, is often used satisfactorily as a binder, would seem to prove this hypothesis.

Of the most common stones used for macadam work, it has come to be generally accepted that trap rock (diabases, diorites, and some other rocks of an igneous metamorphosis) is the best. In the order of merit there follow the felsites, hornblendic granites, the harder limestones, schists, and quartzites. It is not safe, however, without investigation and tests, to say, for instance, that a granite is always better than a limestone, since some of the noncrystalline limestones are often found to be far superior to the large crystalled granites. This may also be found to be true when other rocks of the foregoing list are compared with one another.

Undoubtedly the best laboratory tests of rocks for road building are those made by the Public Road Office at Washington, D. C., of which Mr. Logan Waller Page is director.

That department undertakes to make tests and analyses of stones without charge. It has done much excellent work, and tests and reports on tests are made with admirable promptness. The nature of the tests as made by the Public Roads Office will not be discussed here. They include everything hereinbefore referred to concerning tests of rocks and much more, and they have been completely described in the bulletins of that department.[1]

Bituminous Materials.

The writer pauses before entering upon the discussion of the tests of bituminous materials which may be used in road work. While there is no doubt that this material is the most interesting

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[1] See U. S. Dept. of Agriculture, Bureau of Chemistry, Bulletins 7, 9, and 85.

that has so far entered into the construction of road surfaces, it is so new that no standards have been fixed.

The necessity for the use of such materials on our rural roads is wholly due to the rapid change in traffic conditions from horse-drawn to self-propelled vehicles. Nor is it known precisely why motor vehicles require so different a kind of road surface. Much has been said and written, and the writer of this paper acknowledges his own errors in that particular, about the suction caused by the tires of such vehicles. While suction may play some part in the erosin of road surfaces, it is coming to be recognized that the principal source of difficulty lies in the distintegrating action of the rear wheels of motor vehicles. The tractive power, being applied through the rear wheels, results in a tangential stress upon the surface, instead of a pressure normal to the surface, as in the case of the horse-drawn vehicle.

Until comparatively recently it has not been necessary to provide against any such tangential stress; but no macadam road which will receive much motor vehicle traffic should now be planned without taking it into consideration.

Thus far bituminous materials only seem to offer a remedy for the difficulty at a cost which is reasonable, and the coal tars, asphaltic oils, and asphalts are the materials to which road builders have turned their attention in their search for a binder for the broken stone.

The writer is aware that the title of this paper mentions particularly simply tests. There is no such thing as a simple test of bituminous material. There is no branch of chemistry which gives the chemist more trouble than the analyzing of materials containing bitumens.

It is true that the coal tars have been used for many years, here and abroad, for sidewalk purposes, and to some extent in roadways, and that some of the men who have handled the materials have become more or less expert in its use. Indeed, some of these men claim to be able to judge of the quality of a tar when heated by watching it drip off the end of a stick or by chewing it. But these tests are rather too crude for the engineer, and the expert chewer cannot describe his sensations accurately enough for insertion in specifications. The results secured in the use of tar also indicate that these empiric methods are too crude, since, while some of the work done has been excellent, other tar constructions have disintegrated rapidly.

All this leads the writer to the belief that the chemist must, in a large measure, work out this new problem for the road builder.

The coal tars have been used sufficiently in the past in road building to indicate that to be of substantial benefit they must be partially refined and possibly combined with other materials. Unless they are treated so that all the water, the naphthas, some of the light oils, and the ammoniacal liquors are removed, they will prove of little value. But just what the permissible specific gravity and

percentage of free carbon, and what the viscosity and other characteristics should be, are questions of greater difficulty.

The chemists, acting with the engineers, are working diligently on these questions, and it is hoped that by their combined efforts the essential characteristics will be standardized.

The asphaltic oils likewise promise to be useful as binders for macadam and gravel roads; but even less is known of them than of the tars. It seems to be reasonably safe to say that they should be free from water, and that no oil which has a base of paraffin should be used. The value of the oil should depend on the amount of bitumen contained in it. Oils having a relatively low percentage of bitumen are useful for surface application to alleviate the dust nuisance; but for use as a binder in gravel or macadam work it now seems that those oils which have the greatest percentage of bitumen will prove most economical.

It is an open question whether the best asphaltic oil is such as is made up synthetically by thinning down asphalts with lighter oils or fluxing oils, or whether the best oil is secured by stopping the refining process at just the right point and before the refining is carried to the hard asphalt stage. It would appear that the first process should give a product more uniform than the latter, but which process is the better is not yet determined.

The asphalts which are being experimented with as binders are mostly of those made from asphaltic oils. No one knows whether they will prove more economical for use than the so-called natural asphalts, such as the Trinidad or the Bermudez. Lacking the test of time, the oil asphalts appear to be cheaper.

The following specifications will give some idea of the complexity of the artificial binders here under discussion. They are such as have been prepared for the Massachusetts Highway Commission by Mr. H. W. Clark, Chief Chemist of the Massachusetts State Board of Health, and represent the results of a considerable study of the materials in the laboratory and in the roads. It is not claimed that they are in perfect form; but the Commission is using materials conforming to them this year in its treatment of many miles of road. The specifications are intended to represent what have been so far offered as the best materials for bituminous road binders.

Refined Tar.

Section 10a. The tar must be uniform in color, character, appearance, and viscosity, and must have the following qualities:

a. It shall contain not more than 0.5 per cent. of mineral matter or dirt.

b. It shall have a specific gravity between 1.18 and 1.25.

c. It shall not contain more than 14 per cent. by weight of free carbon.

d. It shall contain no body that distills at a lower temperature than 225° C.; not over 10 per cent. by weight shall distill below 270° C.; and it shall contain at least 65 per cent. by weight of pitch

and bituminous material remaining after all bodies up to 360° C. have been distilled.

e. When 20 grams are heated in a flat-bottom dish 3 inches in diameter for twenty-one hours in an oven kept at a temperature of 100° C., the loss shall be not more than 10 per cent. by weight.

f. It shall be of such viscosity that 60 c.c. measured at room temperature (78° F. or 26° C.) shall, when at 100° C., be not less than 85 seconds and not more than 240 seconds in passing through a viscosimeter orifice 5/64 of an inch in diameter when acting under a head of 4¼ inches.

g. When 12½ per cent. by weight of the material is mixed with 87½ per cent. by weight of sand, of such a grade that all will pass through a sieve having 10 meshes to the linear inch and practically none through a sieve having 100 meshes to the linear inch, and briquettes made 3 inches square and ½ inch thick, such briquettes will so harden in seven days at ordinary room temperature that when laid flat and held by their edges by two parallel knife-edge bars, they shall not bend when a weight is suspended from a third knife-edge or parallel bar placed across their center until this weight reaches 200 grams, and shall not break at less than 250 grams, and the weight causing bending shall not be greater than 80 per cent. of the weight causing breaking.

Asphaltic Oil.

Section 10b. The oil submitted shall be of a uniform color, appearance, general character, and viscosity, must contain no bodies not naturally present in an asphaltic oil, and must fulfill the following requirements:

1. It shall not contain more than 0.5 per cent. of dirt or adventitious mineral matter.
2. It shall have a specific gravity of at least 0.97.
3. It shall not contain more than 1 per cent. of matter insoluble in carbon bisulphide, and should not contain more than 10 per cent. insoluble in petroleum ether.
4. It shall contain no body that distills at a lower temperature than 250° C., and shall not lose more than 55 per cent. by weight by distillation to 360° C.
5. It shall be of such viscosity that 60 c.c. measured at room temperature (78° F. or 26° C.) shall, when at 100° C., be not less than 5 minutes nor more than 10 minutes in passing through a viscosimeter orifice 5/64 of an inch in diameter when acting under a head of 4¼ inches.
6. When 20 grams are heated in a flat-bottom dish 3 inches in diameter for twenty-one hours in an oven kept at a temperature of 100° C., it shall not lose more than 5 per cent. by weight.
7. When 12½ per cent. by weight of material is mixed with 87½ per cent. by weight of sand, and briquettes made 3 inches square and one-half inch thick, these briquettes must keep their shape and show some binding together.

Oil Asphalt.

Section 10c.

1. The asphalt submitted shall be of uniform color, appearance, and character, and shall contain no body not naturally present in an oil asphalt.
2. It shall not contain more than 1 per cent. of dirt or adventitious mineral matter.
3. It shall have a specific gravity between 1.00 and 1.10.
4. It shall not contain more than 1 per cent. of matter insoluble in carbon bisulphide, and should not contain more than 30 per cent. insoluble in petroleum ether.
5. It shall contain no body that would distill at a lower temperature than 225° C., and should not lose more than 40 per cent. by weight by distilling to 360° C.
6. When 20 grams are heated in a flat-bottom dish 3 inches in diameter for twenty-one hours in an oven kept at a temperature of 100° C., the weight shall remain practically constant.

Conclusion.

The writer is aware that he has failed to include in this paper many tests, simple or otherwise, of a great variety of materials which enter into the construction of a modern road. No mention has been made of tests of cement, steel, clay pipes, paint, etc. To have included them would have made this paper unduly long, and would, perhaps, have taken it beyond the scope intended by the committee of the Congress which assigned the subject to the writer.

The simplest and best test of road materials is their behavior under actual usage during a term of years. All accelerated tests may lead the investigator into error, but often it is not possible to wait for time to show results.

Such is the case with the use of a bituminous binder, which, as has already been stated, is the most interesting subject which the world's road builders have before them at the present time.

Of the three mentioned in this paper, the tars are best known. Some excellent results have been secured by their use, and many failures have occurred. There is no doubt that a specification for the best tar composition will soon be available. As for the asphaltic oils and the oil asphalts, not so much can be said at the present time. They have not fully demonstrated their usefulness in the Eastern States, at least, and they must be watched for a term of years. They give great promise, however.

It must not be forgotten that it may cost less to resurface a road with an inferior material, often applied, than to use the new materials now entering into rural road construction.

The cost per unit per annum is the ultimate test of the usefulness of any material.

SENSIBLE UTILIZATION OF CONVICT LABOR.

BY HORATIO S. EARLE, PRESIDENT, NATIONAL CONVICT LABOR GOOD ROADS ASSOCIATION, DETROIT, MICHIGAN.

We are our brother's keeper, intensely, when we have him incarcerated.

We are in many cases as guilty as the convict of a crime, for the burden of properly bringing up the young rests upon the adults, and if for our neglect he is a convict, then remember that it is our fault, and let our dealings with him show our knowledge of it, and do all we can to ameliorate our crime.

Then the paramount matter is, what can we do for the convict? We can give him education, that will uplift him, so he can see his former self as others did see him.

We can give him good food, good clothes, good home, and give him good hard work, all of which will help to make a stronger man out of him, physically, morally, and, we will hope, spiritually.

Education, food, clothes, home for him are easy things to do; but what kind of work we shall give him is quite another thing. But work he must have, or become worse than when he received his sentence.

Shall we take away from honest men and women nice, easy work to do, and give it to him?

Shall we give him work manufacturing merchantable goods, so as to place these cheaply made goods in competition with those made by men paid a living wage?

We have already committed one crime, the crime of not properly bringing up the man; and he it is that we have incarcerated for his and our crime. He has to suffer for both. Shall we commit another crime, and ask others to suffer for our criminality?

It is nothing less than a crime for states and the United States to sell the labor of convicts at a less price per human-ability kilowatt than is paid in a family-supporting living wage.

Shall we, for the sake of furnishing loyal political party workers jobs in nice clean factories, whose talents in many instances do not furnish them with an ability to sucessfully run a blacksmith shop, allow state slave labor to compete with honest men, and allow the taxpayers to be taxed for capital to run unsuccessfully a state factory to compete with private capital, and so put a burden upon the shoulders of both?

One crime we are already guilty of, shirking our duty to the young; and to that we are going to add two more, harming labor by unjust competition, and capital by tax capital squandered.

Work these men must have, lots of it, and good hard work.

What shall we give them to do that will not do injury to honest labor or private capital?

The almost insurmountable, yet very desirable, thing that is needed to be done in each state in the Union; and let the United States do the same.

What do I mean?

I mean, let Michigan build a concrete arch bridge two hundred feet above water level across the Straits of Mackinaw, even though it takes fifty years for the state to do it, and use convict labor in doing it.

This by private capital is insurmountable, but with state convict labor possible.

After such a bridge was completed, a toll could be collected from all railroad companies using it, and it would furnish funds to support the penal institutions of the state to the benefit of our posterity, that we should be as much or more interested in as we are in ourselves.

I am not acquainted with the desirable, yet insurmountable, things in the state of Washington. It may be that you need an enormous bridge, or perhaps a tunnel, through Mt. Rainier. Use your convicts for that purpose. Then, and then only, will you or any other state be employing sensible ways of using convicts, which will benefit them, harm neither labor or capital, and be a great, lasting benefit to state, nation, and world.

TELFORD ROADS.

By Walter Wilson Crosby, Chief Engineer, Maryland Geological Survey, Highway Division.

The history of road making extends over a period of 2,500 years. The Romans learned the art of making paved roads from the Carthaginians, and the Roman roads have always been regarded as models from which to copy and plan for present-day work. The Incas in Peru built extensive roads, according to Humboldt "not inferior to the most imposing Roman roadways." The early French roads were constructed on the Roman method until about the beginning of the eighteenth century; but after about 1764 the methods were considerably modified by M. Tresaguet, and later, after McAdam had achieved so much success in the British Isles, still further modifications were adopted in 1820.

Perhaps one of the most striking features of the older methods was the attention given to and the expense incurred in providing the most solid foundations. These were frequently three feet in thickness, composed of several layers of large stone. The early French methods simply reduced the thickness to about one-half that of the Roman foundations, and later Tresaguet reduced the foundation to one layer of large stone, eight to twelve inches high, set on edge—a forerunner of what is now called "Telford."

In August, 1757, Thomas Telford was born in the district of Eskdale, county of Dumfries, Scotland. Learning the trade of a mason, he studied architecture in Edinburgh and London, and, being a man of great ability, soon established himself as a leading engineer.

Primarily Telford was a bridge builder; but he carried out many other engineering works, particularly that of laying out and constructing new roads. He was extremely successful in building nearly one thousand miles of roads in Scotland by contract. He let 120 contracts for this work, extending over a period of 18 years, and the work was done with an economy before unheard of, and which resulted in extending his fame widely, and to his being called as consulting engineer on various engineering projects in Europe.

One year previous to the birth of Telford, was born another famous road maker, John London McAdam, at Ayr, Scotland. McAdam spent his youth in the United States of America, returning to Scotland in 1793. The rest of his active life was passed in road work in Ayrshire, Falmouth, Bristol, Perthshire, etc. His success was such that he is generally considered a pioneer of good road construction and administration, and entitled to the reputation of a public benefactor.

It will be noted that Telford and McAdam were contemporaries. The reputation of each will long survive their work, and justly so.

In many ways they worked along identical lines. To-day we separate or identify them by one difference in particular; that is, in the matter of the foundations preferred by each.

McAdam preferred to consolidate the natural soil by drainage, by reinforcing it with gravel, or by similar means, and then to place the surfacing coat of broken stone directly on the prepared subgrade, increasing the thickness of this layer of stone as might be necessary over weaker subgrades. Telford preferred to follow the older method, and provide between the natural soil and the surfacing coat a pavement of larger stone for the support of the surface.

Since the passing away of the man whose name is now attached to it, this subpavement has been repeatedly tried by nearly every community proceeding with the work of road improvement, in the early stages of its work, and abandoned in nearly all of them.

Undoubtedly such a foundation accomplishes its aim—to provide sufficient solidity for the surface. But, expedient as it may have been under the peculiar conditions of its use by Telford, it is questionable if its use did not at the same time produce other conditions which ultimately might furnish arguments against it. It is, of course, probable that conditions where Telford worked were such that his well-known aim of economy was met with the use of the pavement foundation. Conditions have, however, so changed since his time that it is perhaps doubtful if Telford himself would now repeat its use, at least to its former extent, in the same localities, and it is most probable that, under the changed conditions now existing here with us, he would abandon, to a large extent, at least, if not wholly, its general use.

When the older road builders were securing their results, labor was cheap, material plentiful, and in many cases expenses of comparatively little moment. Coarse stone for the foundations were less hard to secure than the broken stone for surfacing. The latter were slowly broken by hand. Steam rollers were unknown. Records of first cost were not clear in many cases, and no records of maintenance cost, for comparison with a census of the traffic over the finished work, were available for pointing out what was economical construction and what was not.

Further, it is doubtful if a fair comparison of results of the methods in use by the Romans, and followed by Telford, can be made with similar work elsewhere, because of a lack of knowledge of, or lack of record of, the variance in the local conditions of climate and use. We do know, however, that Telford was tried in France, and abandoned for Macadam.

In this country, with its diversified conditions, both Telford and Macadam have been used under all sorts of circumstances, and the consensus of opinion seems to be against the use of Telford, except under most extraordinary circumstances.

Nowadays, with the rise in valuation of even rough stone, with the increased cost of labor, with the advent of the steam roller and the modern stone-crushing machinery, with the changed conditions of vehicular traffic, and especially, in many parts of this country,

with the existing variety of climatic conditions, such, for instance, as long-continued rainy weather, long periods of drought, deep freezing, or alternate freezing and thawing, the best practice seems to unite in the abandonment of Telford foundations.

Numerous trials of it have been made in different localities, and even to-day one occasionally hears of some state, just starting in on modern road work, which adopts in the early days of the work the Telford road as its standard. Later, it will generally be found that the inelasticity of this adoption has resulted in a reversal of policy.

In the effort of the inexperienced to improve on previous results, by building apparently more substantially, is lost sight of the fact that rigidity and high first cost may not always be most advantageous, and the fact that frequently permanence may require to be sacrified to some extent for the sake of economy, or of comfort and convenience.

A Telford base will certainly give rigidity and resistance to vertical displacement under occasional heavy loads. It is open to the objection, however, of being frequently too rigid and unyielding for the economical maintenance of the surfacing on top of it. Such a base acts as an anvil, upon which the pieces of stone in the surfacing may be more easily reduced to a powder by the hammering effect of the heavily loaded wagon tires.

Where frost penetrates the ground to the depth of a foot or more, it has been proved by general experience that the large stone composing the base will work up into and destroy the surfacing, as well as thus losing their own lateral support under such frost action, and consequently much of their power to support loads. When the base becomes so displaced, the maintenance of the surface is rendered still more difficult and expensive.

In many instances, the maintenance of a bond between the broken stone surface coat and the paved base has been found extremely difficult under the peculiar conditions of the local traffic.

There are, moreover, a very few occasions, if any, where the necessary firmness for the base to the macadam surface cannot be secured by other methods, both freer of objections and less expensive, than by the Telford base.

There may be instances where Telford would be demanded by conditions; but in all the experience of the writer he can recall no case where the demands could not have been better met by some other form of construction, and he is familiar with instances where it has been used with unsatisfactory results.

It should not be understood from the foregoing that Telford invariably required the pavement now bearing his name under the surfacing. As a matter of fact he did not, and in No. 5 of his famous "General Rules for Repairing Roads" he says:

"Where a road has no solid and dry foundation, it must be constructed anew. It must be well drained, and put into a proper form. Upon the 18 center feet of stones must be put '(set by hand)' forming a layer of 7 inches deep. Soft stones will answer, or cinders, particularly where sand is prevalent. Where a road has some foundation, but an imperfect one, or it is hollow in the middle, all the large stones appearing on the surface of it must be raised

and broken; the 18 center feet of it must then be covered with a coating of broken stone, sufficient to give it a proper shape, and to form a bed of solid materials of at least 13 inches in depth.

"Where a road already has a good foundation, and also a good shape, no materials should be laid upon it, but in their layers, for the purpose of filling ruts and hollow places as soon as they appear. Stones broken small, as above described, being angular, will fasten together. In this way a road, when once well made, may be preserved in constant repair at a small expense."

However, the generally accepted distinction between the work of McAdam and Telford is the absence or presence of the paved base, and such roads as have this base are invariably called "Telford Roads," and the base itself is referred to as "Telford," just as the broken stone surface is called "Macadam."

While Telford, the engineer, is now perhaps best known by the pavement he advocated, under some circumstances, as a base for the broken stone surface, his fame as an engineer will remain long after the use of the pavement for that purpose shall have been everywhere abandoned, and the sound common sense of the man Telford, as well as that of his contemporary, McAdam, will always be honored by English road makers as is that of Tresaguet by the French.

THE COST OF ROAD BUILDING AND METHODS OF REDUCING THE COST.

By Halbert P. Gillette, Managing Editor of Engineering-Contracting, New York.

There are approximately ten miles of wagon roads in America to each mile of railway. No one knows exactly what it would cost to build the average single-track railway, and there is very little else but single-track at present; but I should put the cost at not far from $35,000 per mile, exclusive of right of way and station grounds, but including buildings and equipment.

What will a good macadam road cost per mile? Obviously no very definite answer can be given to such a question, without knowing the local conditions, as well as the design of the road; but I should say that a fair average cost is not far from $7,000 for a double-track macadam highway. By "double-track" I mean a macadamized roadway 16 feet wide, so that two vehicles can readily pass at any place.

The ratio of cost of a single-track railway (with all its appurtenances) to the cost of a double-track macadam road is, therefore, about 5 to 1. But, in my opinion, there is no more necessity of building double-track wagon roads throughout the country than there is of building double-track railways. If, therefore, a single-track (8 feet wide) macadam road could be built for $3,500 a mile, and it can be, the ratio of cost of a single-track railway to a single-track road would be 10 to 1. Consequently. since the mileage ratio of railways to roads is exactly reversed, it would cost no more to pave every road in America than it has already cost to build all the railways. In fact, it would cost less, for the right of way for wagon roads has rarely to be purchased.

It is not my intention to attempt to prove that it would be in the interest of economy to pave every wagon road in America, although I firmly believe that America will not be many years longer in reaching the present condition of England, where one may ride for a month and never see a "dirt road." But, to hasten that desirable time, it is essential that both the civil engineers who design roads and the taxpayers who foot the bills shall cease demanding double-track roads, regardless of the amount of traffic that the road is to carry. What we need in America to-day is *length,* not *width,* nor *thickness,* of paved wagon roads. I use the word "pavement" to include macadam or any other artificial flooring laid upon the earth to distribute the wheel loads over the subsoil and to keep the subsoil dry.

A pavement may be likened to a snowshoe, because the main function of each is to distribute a concentrated load over a soft material beneath, so that the concentrated load will not sink into the soft material. This is the main function of every pavement, and the designing engineer can never produce an economic design

of road without clearly understanding this function. It is obvious that the per mile cost of macadam, or of any similar pavement, depends largely upon the number of *cubic yards* of pavement per mile. The length of a mile is fixed; but the other two dimensions of a pavement are not fixed. The width depends upon the amount of traffic to be carried, or at least it should. The thickness depends upon the softness of the subgrade and upon the skill of the designing engineer.

As I have said, it ought to be evident to any one that, if the traffic of the country does not warrant double-track railways, it certainly does not warrant double-track wagon roads, as the standard of general use. However, it is hard for an engineer, and still harder for a farmer, to think of building a paved roadway on which two vehicles cannot pass wherever they happen to meet. We know that there are innumerable unpaved mountain roads, and many dirt roads elsewhere than in the mountains, where there is but one trackway; turnouts being provided at short intervals. We also know that there are many macadam roads paved only six to eight feet wide, and giving excellent satisfaction. Still the mania for building double-track wagon roads persists, regardless of all economic reason.

My conception of a standard road is one having a paved trackway 8 feet wide, with turnouts 50 feet long every 400 feet, the paved width being 16 feet at the turnouts. This is equivalent to adding one foot of width to the entire length of the road, so far as cost is concerned. Of course, the entire road should be properly graded and crowned for a width of at least 20 or 24 feet between gutters or ditches; but the paved portion should be only a narrow strip, 8 feet wide, at the center, unless the traffic is dense enough to keep vehicles waiting a very considerable percentage of their time at the turnouts.

Such a design may not appeal at first to automobilists; but we must remember that country wagon roads should be designed primarily for business use, and secondarily for pleasure. Moreover, it is possible so to treat the earth shoulders or sides of a paved road as to make them excellent roadways for pneumatic tired vehicles, particularly where the vehicle does not run constantly on the earth shoulder. Of this I shall speak later.

We come next to a consideration of methods of reducing the thickness of the pavement. The old Roman roads were built of layers of stone often 36 inches thick. This was magnificently Roman, but it was poor engineering. Still there are many people who cannot free themselves from the impression that any structure that has endured many years must have been well designed. There is a popular fondness for whatever is massive. American engineers, however, have but one criterion as to excellence of design, and, briefly stated, it is this:

That structure is best designed which performs its function with the minimum of cost for interest on first cost plus the annual expense of maintenance.

When this criterion is applied, it is evident that even a macadam more than 6 inches thick is usually an uneconomic construction. I intend to show, briefly, that 6 inches of thickness is considerably more than need ordinarily be given to a pavement.

A pavement is like a snowshoe. The softer the snow, the larger the shoe should be in order to spread the load. The softer the subsoil, the thicker the pavement must be, for the same reason. It is commonly said that the unit pressure on the subsoil, as transmitted through a pavement, varies inversely as the square of the thickness of the pavement. This is a conservative estimate; for, several years ago, I made some tests, in collaboration with Mr. Richard T. Dana, that proved that the pressure transmitted through a granular mass varies inversely as the cube of the thickness of the mass. An illustration and description of the pressure gauge that we used in these experiments will be found in "Engineering-Contracting," June 9, 1909.

If snow is consolidated even a little, the size of the snowshoe can be greatly reduced. In like manner, if the subsoil is consolidated, the thickness of the pavement can be reduced. The trouble in the past has been in effecting a uniform consolidation of the subsoil to any considerable depth below the surface. The experiments above referred to show why it is that even a 10-ton steam roller is so inefficient in compacting the earth subgrade of a road. If the pressure transmitted through a granular mass decreases inversely as the cube of the thickness, it is evident that at a depth of six inches below the surface the pressure due to the load is less than one two-hundredth, or one-half of 1 per cent. of what it is at a point one inch below the surface, for the cube of 6 is 216. This is probably not the exact ratio for such heavy loads as a steam roller, but the figures serve to indicate in a general way what happens.

A few years ago a method of compacting earth was invented by a California road builder, John Fitzgerald, which, in my opinion, is destined to do more toward reducing the cost of roads and streets than any single invention since Blake made the rock crusher—another American contribution to the science of road building, by the way.

Fitzgerald observed the action of a flock of sheep which passed over a road that he had just plowed up, and he was struck by the wonderful compacting effect of their feet upon the plowed soil. After they had gone by, he found that an ordinary plow would not penetrate the sheep-compacted soil, and he was very angry. He remarked to his partner that, if the sheep had only been considerate enough to have waited until he had properly crowned the road, they would have not only saved him the expense of rolling it, but would have done the job infinitely better than he could do it with a roller.

"Suddenly," said Fitzgerald, in telling me of the incident, "a thought struck me. I couldn't afford to hire a flock of sheep to do my rolling; but why couldn't I invent a flock of sheep?" And he did. He made a roller with projecting "sheep's feet," as he called

them, or tampers, as they are now called. The tampers project from the drum about eight inches, and sink to the hilt in plowed soil, thus starting their tamping action at the bottom. As the rolling tamper is pulled back and forth over the earth, the tampers gradually ride higher and higher, until finally they ride upon the consolidated mass, which is the test of sufficient rolling.

If there are any lumps in the plowed earth, a spiked disc harrow is used to pulverize the clods before the rolling tamper is used. Most soils require sprinkling with water to secure the most effective consolidation. It is not unusual for a soil weighing 90 pounds to the cubic foot to be thus tamped until it weighs 120 pounds per cubic foot. An even greater density can be secured by mixing gravel with a loamy soil.

As yet, this method of compacting subgrades is scarcely known outside of the state where its inventor lives; such is the slowness with which all improved methods of construction come into general use.

By compacting the soil uniformly to a depth of about six inches, it is possible to reduce the thickness of the pavement to three inches. This has been done with many asphalt-macadam pavements laid in California on a tamped base.

The tamping never costs more than 1½ cents per square yard; but, if the soil is very tough and breaks up in large clods, requiring harrowing, the cost of the plowing, harrowing, and sprinkling is occasionally as high as 2½ cents per square yard.

Let us see what is saved in cost of construction by Fitzgerald's method of tamping subgrades. At the very least, the pavement can be reduced two inches in thickness, until it is four inches thick. If the soil is of a character that compacts well, the pavement need be only three inches thick, which is half the present standard thickness for macadam or asphalt-macadam.

Macadam rarely costs less than $3.60 per cubic yard, measured rolled in place, at which rate each inch in thickness costs 10 cents per square yard. This makes the cost of a six-inch macadam 60 cents per square yard. I shall not go into the details of the cost of macadam or of other pavements, for I have given them in my books. Assuming, for the present purposes, an average cost of 60 cents per square yard, a six-inch macadam pavement sixteen feet wide costs $5,632. Grading, drains, culverts, engineering, etc., usually bring the total cost up to $7,000 per mile.

Now, if we cut the thickness in two, reducing it to three inches, and cut the width in two, reducing it to eight feet, we have a macadam pavement one-quarter the present standard cost per mile.

Such a macadam road eight feet wide, with turnouts every 400 feet would cost about $1,600 per mile, exclusive of grading, tamping the subgrade, etc. If the entire roadway is plowed and tamped for a width of twenty-seven feet, at the cost of 3 cents per square yard, we have a cost of about $500 per mile. I am well within bounds, therefore, when I say that a macadam road, paved for a single track, can be built in most localities for about $2,100 per mile,

after the grading has been completed. Grading varies widely, but seldom averages more than 3,500 cubic yards per mile, which can be done at a cost ordinarily ranging from 20 cents to 35 cents per cubic yard.

If culverts and bridges are already in existence, it is evident that a good single-track macadam road can be built ordinarily for about $3,000 a mile, including grading, provided it is built by contract, and not by day labor. What it will cost by day labor I should not even attempt to guess. Usually the cost is 50 per cent. to 100 per cent. higher than where the work is done by contract. Telford, the famous English road builder, has said that, in the long run, the day-labor method is two to three times as expensive as the contract method of road building.

I have spoken thus far of macadam as the standard pavement, but there are many localities where the old-fashioned macadam should no longer be built. I need not dwell upon the destructive effect of rapidly moving pneumatic tires upon macadam, for, thanks to the Office of Public Roads, this phenomenon has been carefully investigated. Some sort of a bituminous binder—asphalt, asphaltic oil, or tar—seems to be necessary, at least for the top wearing coat, wherever macadam is subject to very much automobile traffic.

Nor shall I discuss the latest development of asphaltic oil roads in California, where asphaltic oil is mixed with the soil and tamped into a dense mass that serves excellently under moderate traffic. The latest development of this method of road building consists in covering the tamped base with gravel or broken stone, which is mixed with asphaltic oil and also tamped down, producing a sort of asphalt-macadam at a cost often as low as 30 cents per square yard.

It is evident to all who read current engineering literature that we are in an era of development of road making methods such as has never been seen before by any one now living.

This does not mean that macadam is to be abandoned entirely. I am satisfied that macadam will remain the most economic type of road pavement in many localities, where stone is cheap, bitumens are dear, and motor car traffic is light.

Asphalt or tar macadam, of one sort or another, is likely to become a standard wearing coat where heavy motor car traffic exists; but this does not mean that this wearing coat will be of any such thickness as has been common with ordinary macadam.

Ordinary earth, mixed with asphaltic oil or tar, and tamped solid, will be extensively used, not only as a base for an asphalt or tar macadam wearing coat, but for the shoulders on each side of the asphalt or tar macadam; and where the traffic is moderate, and the soil suitable, no asphalt macadam wearing coat will be needed at all.

Among other methods of reducing the cost of road work, I would mention particularly the use of clam shell buckets for unloading broken stone from cars into wagons, and the use of wagons drawn

in trains by traction engines. Broken stone can be most economically spread by a small scraper pulled by two horses. After being roughly spread in this manner, potato hooks or rakes should be used to complete the even spreading of the surface.

We are accustomed to think of American road making as being only an imitation of English and French road work. It may not be amiss, therefore, to enumerate a few of the American inventions that have served to reduce the cost of road construction to such a degree as to put "good roads" within the reach of every American community, despite the fact that the wages of American road builders are from two to three times what they are in England or France.

To begin with, we have the rock crusher, invented by Blake.

Scarcely of less economic importance in macadam road work is the rock drill, also an American invention, the perfection of which should be credited to several different men.

I do not recall the name of the inventor of the wheeled scraper for excavating and transporting earth, nor the "road machine," nor of the "elevating grader"; but every one of these important earth-moving machines is an American invention. So, too, is the bottom dump wagon, and the small scraper for spreading broken stone.

The steam roller is a French invention, but the rolling tamper is American.

The use of asphaltic oil for "oiled road" construction is a California invention, dating as far back as the coming of the Spaniards to Lower California; for the paths around many of the old Spanish missions were treated with crude asphaltic oil.

America can, therefor, claim to have been the first to use a bituminous binder for roads.

There is certainly no lack of knowledge of how to build roads at low cost in America, nor of how to build them well. With the development of the contract system of road building, and the passage of "state aid" laws, has come a wonderful impetus to road building. But the passage of these laws and the abolition of the old day-labor system of road building are due primarily to the campaign of education by the Office of Public Roads of the United States Department of Agriculture, and by the various organizations and engineering publications that have worked in harmony for the betterment of the rural highway.

SURVEYS AND MAPPING.

By George C. Diehl, Buffalo, N. Y.

Comprehensive highway laws and liberal appropriations are essential to the construction of properly developed systems of main and lateral highways. Long discussion and carefully planned campaigns of education are usually necessary before such laws and appropriations are obtained. Methods of construction and various engineering questions to a slight extent form part of the preliminary educational work; but the problem of "Surveys and Mapping" is not presented until laws have been enacted and funds appropriated to make such enactments effective. In all large accomplishments the main idea and completed work are of general interest; but the details and intermediate steps which produce the result are not always interesting. The expense of surveys and maps is frequently criticised, especially in localities where few roads have been constructed, and where the highest degree of efficiency has not been obtained.

It is not intended to present in this brief paper any original ideas, but rather to outline the methods in vogue in states (especially New York State, from whose reports many of the below-mentioned statements have been taken) where much road work has been done, and to indicate the advantages and economy of accurate surveys, careful estimates, and comprehensive study of the diverse conditions which confront the road builder. It is believed that the various problems can be best solved by careful, slow, painstaking consideration, rather than by quick decision, without surveys or exact facts, during the progress of the work.

In surveying and mapping, as in all enterprises, the most satisfactory results can be obtained by thorough organization, fixed responsibility, and systematized work. The minor problems must be solved by the subordinate officers, and the more important questions should be determined by the higher paid and better equipped officials. For instance, an assistant engineer is best employed making decisions on minor matters, rather than in conjecturing his probable course if he were the chief engineer. It is more important that the chief engineer's time should not be wasted on lesser details than that the assistant engineer should occasionally fail on a problem too difficult. Fixed responsibility quickly indicates ability, and permits the highest state of efficiency in organization. The engineer's force will, in addition to surveying and mapping, have charge of construction.

The smallest unit should be the field party, and should usually consist of about six men, including an assistant engineer in charge, a transit man, a leveler, a rod man, and two chain or ax men.

Several field parties should be in charge of a resident engineer, with an office suitably located to keep transportation charges at

the minimum. The resident engineer should be assisted by a chief clerk, a stenographer, and a force of draftsmen proportionate to the number of field parties and the work performed by them. If the work is of considerable magnitude and covering the area of an entire commonwealth, three or four residencies should form part of a division under control of a division engineer, with suitable clerical and drafting force, dependent on the nature and amount of work in progress, and with offices conveniently located in the larger centers of population.

The state should be divided into several divisions, and under the control of the chief highway engineer or commissioner, with offices at the state capital. The chief engineer should have a testing laboratory, deputies, clerks, draftsmen, and stenographers, to keep in close touch and perfect familiarity with the entire work, in order that he may render careful, yet quick, decisions on all vital matters, and may outline wise and economical policies.

The chief highway engineer shall, before any surveys are undertaken, issue certain general rules and regulations, which must be rigidly adhered to, in order that the work may be standardized, and no time wasted, in the more important offices, in deciphering note books, etc. Field notes shall be kept in uniform sized books according to a standard system, and shall be furnished from the chief engineer's office, and on the completion of work on any road the books shall be immediately filed in the division engineer's office. Separate books shall be used for each road, and there should be indicated in each book the name, location, and length of the road, the names and duties of the field party engaged in making the survey, and an explanatory table of all abbreviations used. All abbreviations must be in accordance with standard forms issued by the chief engineer, in order that field books may be equally intelligible and easily read in any office in the state. Bench marks, azimuths, culverts, and the character of the soil shall be recorded in tabular form, in addition to the regular notes. At the beginning of each day's notes the names of the field party, their duties, and the date and condition of weather should be recorded. Each field party should be equipped with a small camera, and photographs taken of any bridge, culvert, or special work which will require extra study, consideration, and decision by the chief officials. The films should be listed, and pasted in note books near the corresponding transit notes.

All surveys should be based on transit lines, which should be in or parallel with the center line of the highway. Some time can be profitably expended in locating stone markers or iron pipe which mark the center of highways, as these permanent marks are frequently destroyed during road construction, to the great inconvenience of property owners. All landmarks should be renewed or maintained. The azimuth of each line should be taken, and each transit point or angle should be marked with an iron pin and referenced to permanent objects by at least three measurements. Walls, fences, or other structures, which indicate the boundaries of the road or abutting property, should be located, as well as

buildings within 100 feet of the road, or any permanent structures which may be affected by the proposed improvements, such as changed grades, new ditches, drains, etc.

The magnetic bearing and location of each transit course, property line, and intersecting highway boundary line shall be measured. All private houses, barns, or field drives which lead from the highway should be located, and a tabulated list made, showing their character. Existing paved ditches, curbing, catch-basins, railroad tracks, lines of telegraph and telephone poles, and shade trees should be located, and names of companies owning tracks or poles should be noted. All bridges should be located, and sketches made, showing details of abutments, superstructures, etc. Complete notes, showing actual conditions of such structures, bridges, and abutments, should be compiled. All culverts should be located, and sketches made, showing details, and every one should be designated as "necessary," "good," or "bad," which will indicate whether or not the culvert shall remain or be replaced. The assistant engineer must decide this question by examination at the time of survey, and must also ascertain if waterways or culverts are of sufficient size, as indicated by observation of previous high-water marks, or inquiry of nearby residents. Where new waterways are to be constructed, the assistant engineer should ascertain the area of watershed, and such other information of slope, surface, etc., necessary to compute the size of opening required. A tabular statement should be recorded, showing the nature of the soil, and the chief town highway official should be required to locate during the previous spring all sink holes, quicksand pockets, and unstable portions of the road, and mark the same by driving wooden stakes at the sides of the road or by other suitable methods. The assistant engineer must furnish detailed report of each portion of the road so indicated, with his recommendations for proper treatment. Surveys are usually made in dry weather, when soft spots are not easily detected.

All quarries, or ledges of rock suitable for road materials and masonry should be located. Samples of the same shall be forwarded to the testing laboratory of the chief engineer, and the amount of rock estimated. The quality and quantity of field stone and gravel occurring on the road shall be likewise determined. All stone should be carefully tested in the laboratory, to ascertain its hardness, tenacity, toughness, absorption, and abrasive resistance. All exposed ledges should be examined to determine the effect of long-continued weathering.

Data regarding the various transportation facilities for carrying material, location of nearest switch, name of railroad, freight rate, etc., should be obtained. The most advantageous locations for stone crushers should be determined, and the ordinary wages of laborers and teams. It might appear that much of this information should be obtained by the contractor to whom the work is let; but experience has demonstrated that, the more detailed the estimates of the engineer, the closer the contractors will bid on the work.

Numerous instances can be cited where the cost of roads have abnormally increased by the failure to locate suitable unworked quarries convenient to the road.

The leveler and rod man should run accurate levels, establish and keep accurate record of a series of permanent bench marks, giving elevation at suitable points, above tide water or other general accepted datum plane.

At each 100-foot station, at each change of grade, and at cross-roads, elevations should be taken to the nearest $^1/_{10}$ foot on the base line, and such other points at either side as may be needed to plot an accurate profile and cross-sections of the road. Usually levels need not be taken outside the boundaries of the highway, unless a considerable cut or embankment is to be made, or the highway to be widened. Cross-sections shall be taken where there are marked changes along the beaten path. Elevations should be taken at front corners of all buildings which are apt to be affected by the proposed improvements. Cross-sections should be taken near each culvert, to permit accurate computations of culvert excavation. Profiles and locations of streams adjoining or crossing the highway should be obtained, if there is any possibility of changing the existing drainage system.

To avoid confusion, a regular routine should be followed in making all locations and taking levels. The rod man and chain man must keep separate notes of all readings on bench marks and all measurements to transit points.

Frequently existing highways have been laid out along old farm or lot lines, without reference to suitable grades or stable foundations. Often 15 per cent. or 20 per cent. grades or poor foundations are encountered, which could have been avoided by making a slight detour. Such new locations can be adopted in many cases at a less cost and with more satisfactory results than attempting excessive cuts or fills on existing roads, with the heavy consequential damage to abutting owners and additional road metal and drainage in soft spots. Whenever a grade is over 5 per cent., and the assistant engineer believes a new location is desirable, he should report the same to the resident engineer, who should personally take charge of all surveys. If there are several available lines, a survey should be made of each, by running transit lines and taking cross-sections extending not less than 100 feet each side of the transit line. Profiles should be plotted and contour maps made, and a most careful study made, including rough estimates of cost. The character of soils should be ascertained by borings where cuttings are to be made. Swamps, woodlands, pastures, cultivated lands, vineyards, etc., should be located, to ascertain the comparative cost of acquiring the new right of way.

Nearly every problem which enters into railroad construction is encountered in locating new right of ways for highways, and instances are frequent where thousands of dollars might have been saved by slight changes in alignment, or grade, which should easily have been foreseen and provided for by proper study.

The final location must be determined by the division engineer, and in difficult cases by the chief engineer, and should take into consideration convenience to the traveling public, length of route, the total amount of rise and fall, subsoil conditions, total cost, the number of culverts and bridges, natural defects to be overcome, and tractive resistance, which depends on a combination of length and grade. Lessening of maximum grades means continual saving in the transportation charges to every user of the highway.

Surveys for acquiring a new right of way, either for widening or making new locations, should be made by a party especially detailed for that purpose. Transit lines should be made, carefully run around each parcel, and the length and bearing of all sides determined. Stone markers or iron plugs should be set to define the lines of property taken, deeds of records of property transfers and road records should be examined, and the entire survey connected with the original road survey. Maps should be prepared in the offices of the resident engineer (which is accessible to highway) in case additional measurements are required.

Plans shall first be drawn on continuous detail paper about 24 inches wide and to a scale of 50 feet to one inch. The transit lines should be drawn, checked, and inked before details are plotted. All details, owners' names, railroads, notes relating to quarries, grade, water, etc., should be neatly placed on map in pencil. Profiles should be drawn on standard continuous profile paper, to a horizontal scale of 50 feet to one inch and a vertical scale of 10 feet to one inch. All profiles should be checked and inked before plotting grade line, which should be determined by the resident engineer and drawn in pencil. Culverts, bridges, crossways, etc., should be indicated on both plans and profiles. Cross-sections should be drawn on standard transparent cross-section paper to a scale of 5 feet to one inch. The surface line station numbers, elevation of center, abbreviations for fences, trees, etc., should be inked.

The proposed grade lines should be adopted after careful consideration by the resident engineer. The amount of excavations should be sufficient, as far as practicable, to make the necessary embankments and shoulders. The old road surface, frequently the result of graveling for many years, should be preserved and used for a foundation as far as practicable. The maximum grade should not be greater than 5 per cent., nor less than ½ per cent., unless authorized by the chief engineer. The value of road depends largely on a properly determined grade. Excessive grade limits the speed, weight of load, and renders drainage problems more difficult. The grade as far as it is practicable should be adjusted not to interfere with existing houses, shade trees, driveways, sidewalks, etc. Changes on grades of over 2 per cent. should be eased with vertical curves, and heavier grades should be in the direction of lightest travel.

The proposed alignment of the road should follow the center line defined by the road record, except where sharp turns can be

avoided, which are particularly dangerous on roads much used by motor vehicles.

The proposed finished cross-section should be determined by the chief engineer. Generally the roadway on main highways should be about 30 feet in width, with 16 feet width of road metaling. The crown on the road metal should be about ½ inch to the foot or 4 inches for a 16-foot width of metaling. The earth wings should slope about ¾ inch to the foot, and the slope to the ditch should not be steeper than 3 inches to the foot. The entire cross-section should be so proportioned that the traffic should be spread, and not follow a single track; also that any vehicle could be driven into the ditch without danger of overturning.

Before determining the character of road metal, a traffic census of the road should be taken by the assistant engineer. The number of horse and motor vehicles should be counted, and their weight estimated, at the hours of heaviest travel. The kind, thickness, and width of road metal should be based on the present and estimated future tonnage per foot width of road, the number and speed of motor vehicles, and the general soil and drainage conditions. The surface should be dry, solid, elastic, dustless, of easy grade, and smooth.

After the proposed alignment, grade, and cross-section have been plotted in pencil on the plans, they should be submitted to the division engineer for his approval, and he should fix a date when the county and town officials could accompany the resident engineer and himself over the road on foot with the plans, and carefully go over on the ground all the suggested improvements, in order that the sound common sense of the farmers along the roads, the special knowledge of the local officials, and the technical ability of the engineers would be combined in the final and completed plans. Conclusions should be reached regarding the kind and width of road metaling, the location and size of culverts, the changes in grade, alignment, and cross-section, the method of providing stable foundations at sink holes, quicksand pockets, and soft spots, the location of underdrains, and the general scheme of drainage, especially where necessary to construct new waterways to carry water from the lateral ditches, the locations of concrete ditch crossings, guard rails, road signs, and guide posts, and the best methods of construction, in order to cause the least inconvenience to the traveling public.

After the results of this inspection and consultation, the lines, grades, and sections as finally determined should be inked, and the drawing traced on uniform size sheets, preferably about 24x36 inches. Celluloid tem plates cut to proper form can be used to draw the proposed cross-sections or plans.

The quantities of the various items should then be computed. The excavation and embankment can be quickly and with sufficient accuracy determined by the method of end areas, using a planimeter to ascertain such areas. The plans should contain all information concerning quarries, transportation facilities, gravel

and sand banks, and in short every fact that will be of value to any contractor in computing the actual cost of construction.

Many contingencies arise during the survey, and it is not intended in this short space to attempt to describe them, or to enter into any intricate engineering problems relating to the construction of large span bridges, which are necessary on many roads, nor to discuss the various types of road construction, which will doubtless be more ably treated by the other speakers.

The methods outlined relate principally to main roads improved with macadam or hard surface. Maps of town or lateral roads, showing locations of bridges and culverts, are of great value to the local highway officials, who are also much aided in improving earth roads by well-directed surveys defining new alignments and better grades.

Highway engineering offers the largest field for individual effort productive of great benefit to the community. At present many engineers do not seek employment in this branch of the public service. Highway positions should be made attractive by insuring permanency in tenure of office, by increasing salaries, and by rewarding successful work with well-earned promotion. The future of the Good Roads movement largely depends upon the ability, experience, and earnestness of the highway engineers.

The best results can be obtained by a hearty co-operation between the farmer, the engineer, and the road user, and the recognition by each of the common sense, skill and perception of the others. Good laws, liberal appropriations, accurate surveys, carefully prepared plans, organization, co-operating interests, fair dealing, and integrity will produce this country's greatest need—Good Roads.

BOULEVARDS.

By Samuel C. Lancaster, Seattle, Washington.

The boulevard of to-day, with its combined effect of nature and art, exhibiting the character and life of a city, had its origin in the rampart, or fortress, of the walled towns and cities of the Old World.

With the city's growth, it became necessary to construct a second, and in some cases even a third, wall, with its accompanying moat. A new fortification having been completed, the old wall was leveled, and the moat filled, thus forming a broad space encircling the city. From this has grown the boulevard of to-day with its beautiful drives, lined with shade trees, flowering shrubs, parks, and promenades.

A striking example of the splendid use which has been made of the ground occupied by the old ramparts is found in the city of Brussels (often called "Little Paris," on account of its magnificent system of boulevards and parks). The massive stone towers which fortified the gateways to the ancient city of Cologne, each of a different type of architecture, were preserved when the old wall was demolished, and they have been made to form a most interesting feature of the present parking system.

In Paris many of the interior boulevards owe their origin to the bulwarks or fortifications which surrounded the city in the Middle Ages. But since 1852 the name has been applied to numbers of thoroughfares which have nothing whatever to do with bulwarks.

When victory crowned the great Napoleon, ambition for his capital knew no bounds, and he determined to make of Paris the most beautiful city in the world. Under his orders triumphal arches, bridges, quays, and public works of great magnitude were begun. Louis Phillippe resumed with new ardor the completion of Napoleon's modern Paris, but it remained for Napoleon III to complete the transformation on a scale of magnificence hitherto unparalleled. Under the direction of Haussmann, plans were matured and the most beautiful boulevards of the world were constructed. The inner and the outer boulevards encircling Paris have an average width of 140 feet throughout their 20 miles. In a couple of districts, for a distance of more than 4 miles, there is a width of 240 feet, while the Champs Elysees from the Place de la Concorde to the Arc de Triomphe has a width of 275 feet.

Of the 12 broad avenues which radiate from the triumphal arch, the Champs Elysees and the Bois de Boulogne are perhaps the most frequented. Under the refreshing shade of the trees which line these avenues, men and women sit at little tables eating, drinking and watching the life of the way, with its kaleidoscopic movement of men and things which animate it from morning till morning comes again. Evening brings electric lights and brilliant il-

lumination, suggesting a city of pleasure, which no one quits without regret.

In nearly every European city the water front is permanently improved with solid walls of masonry, defining clearly the limits of the sea or river, to which access is provided for heavy teaming by a lower roadway; the higher level being reserved for parks and boulevards.

It has been shown that much of the beauty found in the Old World cities is the growth of centuries, while in our country it is scarcely more than 50 years since the development of parks and boulevards was undertaken. We have had to begin at the beginning, yet in a few years we have accomplished great things. With an awakened public interest and the knowledge that it pays, America is now well to the front. It is an established fact that the influence of parks and boulevards increases the value of real estate and tends to lessen the general tax of the city, instead of increasing it.

There is scarcely a city which is not maturing plans, or actively engaged in constructing parks, with a connecting system of boulevards, or widening and extending broad avenues from the business and residential centers, so as to form a fitting approach to some great park or public building. As a nation we are just awakening to the full appreciation of the great work done by Le Enfant in planning our National Capital, and after nearly a hundred years his ashes have been removed to Arlington Cemetery, and a fitting monument will mark his resting place. But his own work is a greater monument than any which we can rear.

When the plan of the commission for the improvement of the Mall has been fully executed, our National Capital will indeed be beautiful, and other American cities will be stimulated to greater action.

The parkways or boulevards of a city, besides connecting parks and affording easy means of communication, should take advantage of beautiful natural surroundings, as has been done in Riverside Drive, New York, where the high bank of the North River has been made to form the crowning effort of the city's boulevard system, surpassing in beauty the famous Thames embankment; or, as in the case of Kansas City, where steep and rocky hillsides, which were before unsightly, have been made to form the principal feature of interest by the construction of parks and boulevards which have raised the standard of all building operations until the new section presents a contrast to the old town as marked as if built a thousand years later.

Charles Eliot has defined landscape architecture as "being the art of arranging land and landscape for human use, convenience, and enjoyment."

In the construction of boulevards it is likewise important to combine convenience with beauty. In some sections it would be best for them to take a certain formal character, without rendering them artificial to a marked degree.

"We are coming to feel that scenery belongs to the people, and that it has its value." We should therefore preserve the most attractive natural features for the constant use and enjoyment of the many against the selfishness and greed of a few.

To quote Morris:

> "Meantime, there is one duty obvious to us all: It is that we should set ourselves to guard the natural beauty of the earth. We ought to look upon it as a crime, an injury to our fellows, only excusable because of ignorance, to mar the natural beauty which is the property of all men."

Charles Eliot helped the city of Boston to appreciate this great fact, and the Metropolitan Park Board is giving to that city the most perfect system of parks and boulevards which has yet been devised.

Chicago is reserving to the people a great portion of the Lake Front, and with a chain of boulevards is connecting the Northwest and the South Side Parking Systems.

St. Paul and Minneapolis form a striking example of what has been accomplished in the Middle West; for together these twin cities have created a magnificent system. Their boulevards and public drives, 34 miles in extent, link together a splendid array of lakes, waterfalls, and rivers, among which are beautiful Minnetonka, the great gorge of the Mississippi River, and the falls of Minnehaha.

With the growth and development of boulevards in this and other countries has come a demand for a perfect road surface, one which shall be smooth, clean, and durable.

Many different materials have been used, wood block, asphalt, bitulithic, macadam, gravel, etc., according to the boulevard's importance and the traffic to be sustained.

Space will not permit further mention of other work of great magnitude in progress in other cities.

In closing, attention should be called to the natural beauty of Seattle's situation. Looking to the east, across Lake Washington, we see the great range of Cascade Mountains, the white caps of Mt. Baker and Rainier reaching into the heavens; to the west, across Puget Sound, the irregular, snow-covered peaks of the Olympics.

In the midst of the city are other beautiful lakes of fresh water, and numerous hills afford viewpoints which can not be excelled. Wherever possible, Seattle's Park Board is seeking to control these situations, and is acquiring the steep slopes and deep ravines, clothed with the rich natural growth, for parkway purposes. A comprehensive plan has been adopted, and a system of boulevards 34 miles in extent will soon encircle the city, connecting all the principal parks.

HIGHWAYS AND CIVILIZATION.

BY HOWARD H. GROSS, ILLINOIS.

The function of the highway in the progress of civilization is fundamental and far-reaching. The more one studies the question, the more he becomes convinced of the truth of the saying of Charles Sumner, Massachusetts' great Senator, who forty years ago gave utterance in a public address to his belief that "the two most potent factors in the advancement of civilization are the schoolmaster and good roads."

It has been the observation of travelers throughout the world that, with the single exception of America, the condition of the highways was a fairly good index of the social, moral, and intellectual standard of the people of any country. France, Germany, Great Britain, and Italy lead the world in art, literature, and science, and here are to be found roads highly improved and maintained in the best possible condition.

It is sometimes said that the reason the roads are bad in our own country is that we are so new and have such an enormous area that the building of good roads is a well-nigh impossible task. We will see later that it is a problem that may be easily solved, and, instead of putting a burden upon the people to do it, will relieve them of a burden many times greater than that they now bear without realizing it. The reason stated above for bad roads here is not sufficient. Australia has splendid roads and a large area. In New Zealand the roads are good. Both these countries are much younger than we are. We must seek another reason.

In passing, it may be interesting to advert to the fact that the present conditions have grown out of certain misconceptions that very largely obtained when the republic was young, and which did not change when the conditions that were responsible for them had entirely disappeared. In colonial days the people settled in the valleys, along the river banks. They lived in a primitive way, and all were producers and consumers as well. What they wore, they made; what they ate, they raised; and business was principally a matter of barter and exchange between neighbors of such surplus articles as they did not require. One settlement had very little to do with, and no great interest in, another settlement over the hills in the next valley. Each community was sufficient unto itself, or nearly so. The country was dotted with these settlements for several hundred miles along the Atlantic coast. It was the day of the home-spun. The spinning wheel and hand loom were everywhere in evidence. How naturally, then, under these conditions, with the strong home rule sentiment that burned with increasing brightness among them, that these people should regard the highways as *entirely a local matter*. What business was it to the people in one community whether the roads in any other

community were good or bad? The people of each individual community assumed the absolute right of control of the highways.

A century or more has passed. To-day it is very different. The advent of the railways, spanning the continent from sea to sea and from the Lakes to the Gulf with bands of steel, the introduction of the factory system, wherein machine-made goods drove out the home-made, and sent the spinning wheel and hand loom to the attic as reminders of a period that had forever gone, when great cities dot the map with millions of hungry mouths to feed, we have a new and different problem. Farming, then primitive, is now done by wholesale. With modern machinery, the cultivator of the soil produces five, ten, or a hundred times more than he needs, and this surplus must be sent to the toiling millions in the towns and cities for their sustenance. In fact, the food products of the world must pass in the farm wagon over the public highways. Farm produce, instead of being consumed within a few miles of where it was produced, as under former conditions, now starts upon a journey that may be 50 or may be 5,000 miles before it is ended.

Thus the function of the highway has completely changed, and, instead of being a matter of local significance alone, it is of continental, and in fact international, meaning. Poor roads increase the cost of delivery, and make the same erratic, uncertain, and intermittent. The delivery depends in a large degree upon road conditions, and these are such that sometimes for weeks at a time not a wheel can be turned. This makes it necessary to store large quantities in the cities, in order to supply the demand for consumption, and increases the cost by a heavy storage charge. Surely anything that so vitally affects the necessities of all mankind, and which is with us so persistently, as bad roads, is a matter of general, and not of local, concern. Hence the new conception that both the state and the nation has and should recognize an interest in the highways, and be charged with some responsibility for their care and maintenance. The highways are the veins of commerce, as the railways and steamship lines are the arteries. They play their part in bringing to the modern home its necessities and luxuries. At the writer's own table he has at various seasons of the year oranges from California, apples from Washington, cantaloupe from Colorado, cranberries from Wisconsin, watermelons from Georgia, pineapples from Florida, bananas from the Antilles, etc., down the line. When we think of this, we realize how our comfort and happiness is involved in the question of transportation.

In the misconception, as above stated, that the roads are purely a local matter, may be found the principal reason for the lack of improvement upon American highways. The new conception, which in its best expression is State Aid, with National Aid coming, will be found the solution of this great problem, the greatest economic and social problem that confronts the people to-day. We believe that America, a land where so many laurels have been won in every field of human endeavor, will speedily grapple with and

solve the road question to meet twentieth century conditions. A better day is dawning. In every state in the Union there are hundreds of earnest and unselfish men and women preaching the Gospel of Good Roads, and what a text they have! In this great work, eminent, if not pre-eminent, is the state of Washington. Here in one of the youngest members in the sisterhood of states, in an empire of boundless possibilities, a land of brilliant achievement and of mighty endeavor, this great movement is going forward by leaps and bounds. It needs no prophet to predict that America's greatest and best in social and industrial life will find its highest expression "where rolls the Oregon."

But we must come to our text—the highways and civilization. How intimately are they linked! How much the condition of the former has the influence to augment or restrict the progress of the latter!

The recent Country Life Commission, appointed by our late great President, found the paramount need of the rural folk was for better schools and good roads. It might better be said good roads and better schools, for with good roads the better schools are sure to follow. The school teacher has done a splendid work, but how vastly greater would it have been if he had had the influence of splendidly kept highways. With these consolidated township schools are easily possible, and that means the country boy or girl will be able to get a *high school education while living upon the farm.* The township school will be the social center, and its influence upon the community life will be one hundred fold more potent than the "little red school houses," of blessed memory and little usefulness, that dot the landscape o'er.

Bad roads have driven tens and hundreds of thousands of the best blood and brawn from the farms to the nearby towns and more distant cities. The country lad, with a strong, vigorous body and active brain, is not content to be mud-bound upon the farm for days and weeks at a time. He is awake to the possibilities that lie within him. He is restless and pulsates with energy. He dreams and longs for the intenser life of the city. He feels an almost irresistible desire to get closer to the nerve center of things. The great outside world is calling to him, and his nature answers the call.

One of the paramount needs of our great country is to bring the city and country folk together on social, educational, as well as business, lines. Give youth of the country at home and in the nearby town the social life his nature demands, and he will be happy, contented, and willing to take up the farm work when his father, by reason of age, must lay it down. Good roads will do more than anything else to establish this condition, by making communication easy between farm and farm, and farm and town. What is more pleasurable than a drive behind a good team over a splendid country road, or in the modern automobile? Is there anything more disheartening to the farmer than to look out upon a sea of mud where the public highway should be, with the town five

miles distant, and be obliged to make the trip on horseback or on foot because of bottomless roads?

The country needs, demands, and must have improved highways, rural delivery, the telephone, and consolidated schools. With these will come brighter days upon the farm, higher and better developed social life, and better living. Distance is no longer measured by the yard stick, but by the clock's tick. Good roads make long miles short. The influence of good roads upon farm life is to dignify it. They make country life better worth living; they broaden, educate, and uplift this most important branch of the commonwealth; they bring the advantages of the church and the lecture platform to the resident of the country districts; they relieve him of isolation and drudgery. Up-to-date roads make up-to-date citizens. With good roads he will come in contact with other men, and take a larger and higher view of life; he will become more useful to himself and more valuable to the community. His interests will go beyond the division fence that separates him from his neighbor. He will read more and become better informed. His wife and daughters will have an opportunity to mix in town society, to the benefit of themselves, and equally to the benefit of their town-bred sisters. This intercourse will speedily remove the apparent distinction between them; they will become better acquainted, and each will find to her surprise that the other has been misunderstood. Jealousies will be supplanted with friendships, and the charm and characteristics peculiar to the town and country girl will be merged and blended in a composite product that will be better for the blending.

Man is a social being. Sociability is broadening and should be cultivated. The city and country have unfortunately only a bowing acquaintance. Lack of social intercourse, which leaves room for the growth of prejudice and jealousy, is largely responsible for this unwholesome and cramped condition. Bad roads are responsible principally for the slight acquaintance that is maintained between the city and the country, and for the absence of the sociability that would naturally follow a closer acquaintance.

There is something radically wrong with the man or woman, who, knowing it well, does not love the country. He who has only had occasional glimpses of it through the window of a parlor car, as he is whirled away on his summer vacation, does not know farm life; he has never drunk the pure, sweet breath of God—never felt the throbbing of Nature's great warm heart. A passing glimpse of the wonderful gardens—the great farms of our country—is not to know them; but to know them well is to love them. With easy access from town to country, farm life will be better known, better appreciated, and the sturdy, wholesome qualities of the country folk will blend with those of the city neighbors, to the betterment of both.

With bad roads as a barrier to free and easy intercourse between the city and the farm, the young mind is warped by wrong impressions, and the soul narrowed by prejudice, and sound symmetrical

education and development are thereby hindered, if not rendered impossible.

It must be admitted that, from end to end of our beautiful progressive country, the greatest drawback to thorough education, the greatest drag on spiritual, mental, and moral development, is the hindrance to free social intercourse between town and country by bad and at times impassable roads. Every farmer knows that there is nothing more destructive to tranquility of mind, nothing that more effectually banishes smiles, nothing more conducive to gray hairs and wrinkles, than to sit upon a loaded wagon and see a splendid team struggling through mud and ruts, while the wagon tongue swings viciously from side to side.

A striking result of the building of roads is the effect upon the pride of the people. The tumble-down fence in front of the farm house is replaced by an attractive picket or woven-wire type; the house is painted; a new barn is built; trees and flowers appear. The people wake up to the fact that life is better worth living, and that, notwithstanding the amount of labor the conduct of the farm requires, modern machinery, with good transportation, reduces it to a minimum.

If one will carefully investigate the burdens, the handicaps, the hardships and drawbacks, due to bad roads, and the money loss to the farmer because of his inability to take advantage of good prices in the markets, the loss to the city dweller because of shortage of supplies and increased cost of transportation over poor roads, he will be appalled at the figures. He will find that a small part of the economies brought about by roads good every day in the year would build and maintain them; that in fact he will be forced to the conclusion that the building of good roads is not an expense, but an investment that will yield a larger and surer return than any other to be found. Take the great Upper Mississippi Valley. Here under the State Aid plan good roads could be built upon all the main highways in the short period of ten years at an average cost to the farmer of ten cents per acre per year. Experience everywhere demonstrates that such roads will add to the value of the farms served by them at least five times the tax upon the farms to build them. Good roads are an asset to the town, the state, and the nation.

Because of bad roads throughout the Mississippi Valley, there is a large drift of the owners of the farms to nearby towns, and the farm drifts into the hands of a tenant. This means that the farm certainly will run down. The fertility of the soil will not be maintained. The landlord squeezes the tenant, and the tenant squeezes the farm. We are fast establishing the conditions that for three hundred years have been the curse of Ireland. The question of keeping the owner upon the land, who will take an interest in it and build it up, instead of wearing it out, is one of the most important problems that the American people must confront. For this reason farm life must be made more attractive, and what will conduce to this end is first class highways. It is a fact that as an

economic and sociological question Good Roads transcends every other consideration. Its influence and beneficence will in years to come permeate the entire fabric of civilization, uplifting, broadening, and ennobling the present and succeeding generations. As the Mound Builders were the highest expression of prehistoric man, so the Road Builder becomes the highest and best product of modern civilization. If cleanliness is next to godliness, then good roads are a means of grace.

THE USE OF BINDING MATERIAL IN BROKEN STONE ROADS.

By William Campbell, Toronto.

The stability of a road is largely dependent upon the bond—that is, upon the filler or bonding material between the stones—and, a necessary sequel, consolidation by rolling. In discussing this detail of road building, it must be understood that other matters have been given due consideration, for a good road must have certain essential features:

(a) The earth subsoil must be well drained, naturally or artificially, so as to make a strong, unyielding foundation. The reason that common earth trails are good in summer is that they are dry. Kept dry by drainage during the wet seasons of the year, they are acted upon to the least possible degree of frost, and, so far as the foundation is concerned, will attain their maximum of efficiency. This is a matter of tile under-drainage.

(b) Ordinary surface drainage must be provided by giving the road a proper camber, and by providing side gutters or drains, leading, with a constant fall, to free outlets. Surface drainage will do much for a road, but it will not do everything, and, unless the ground water is kept at a low point, as defined in the preceding paragraph, surface drainage will not prevent the road breaking up under heavy traffic during wet seasons of the year.

(c) The wearing surface should be a smooth, hard, compact crust, which sheds water readily, and distributes the concentrated wheel load over a greater area of subsoil. The use of a bonding material is a detail, though an important one, in the forming of this surface crust.

As a further practical summary of what is necessary in the forming of a road, we may say that the surface material of metal should be solidified into a compact and distinct crust, free from earth, sand, and other weak materials. The road should be well turnpiked, and given a camber, so as to shed water to the open drains. As a rule, roads when first built should have a camber that is too high; otherwise, they will soon become, through settlement, too flat. Ruts must not be allowed to form, as they prevent water flowing to the open drains. The open drains must have a sufficient fall and free outlets, that water will run off immediately—not soak away. Tile underdrains should be laid so as to lower the water line. This is effective in all classes of soil. Even in light sand, the roads are not cut up so much in wet weather. They remain compact, and there is less dust in a period of drought.

Given these conditions, the best material to use as a binder is an important detail for consideration. A binding material serves several purposes. It unites the stones together, so that they form a solid crust, such as will distribute the weight of wheel loads and

thereby prevents rutting. The binder fills the voids between the stones, and seals the surface against the entrance of rain and melting snow, so that the soil immediately below the stone is not softened by moisture. The binding material aids consolidation under a roller, a feature which is at times given too much consideration by road builders, with the result that inferior forms of binder are used. The binder used is closely associated with the dust problem, a matter of great importance upon roads subjected to constant automobile traffic.

A binder should be effective under all weather conditions of wet, drought, frost, slush, etc. The best type of binding material will cement the stone strongly together, will fill the voids between the stone perfectly, and will tend to a minimum of dust. In loose stones, the voids are about 48 per cent.; in dry rolled stone, the voids are reduced to about 40 per cent.; in wet rolled stone, to about 33 per cent. Under ideal conditions, which, of course, cannot be attained, the perfect binder should just fill the voids of wet rolled stone. More than this weakens the crust; less than this makes the road less waterproof. A good binder will cement and re-cement under pressure of traffic, when the bond has been broken.

For a broken stone road, the standard material is stone screenings, consisting of the dust and chips produced by crushing. These are commonly spread over the surface of the broken stone road to give a smoother surface and to aid in packing. The screenings should be well washed down into the coarser stone by a sprinkling cart preceding a heavy roller. To harrow the screenings into the interstices of loose stone is also an effective means of filling the voids. To harrow the screenings into the stone, flush thoroughly by a sprinkling cart or hose; and then to solidify with a heavy roller is the recognized process of constructing standard Canadian roads. This process will bind the material firmly; the stones obtaining a strong, mechanical clasp between themselves, the screenings acting largely as a cementing material to unite the stones into a waterproof covering.

Clay is occasionally referred to as a binding material, but is a material to which we strongly object. It absorbs water with avidity, is soft and yielding when wet, and its smooth, almost greasy, character when in this condition, renders it a poor binder in wet weather. In dry weather the clay shrinks remarkably, and permits the stones to loosen, so that the road surface unravels. Breaking up in such a condition it is extremely dusty. Clay is thus not an effective bond in either dry or wet weather. It gives a temporary advantage when rolling. A coat or mixture of clay will hasten consolidation under a roller, but the advantage gained is at the cost of durability and service. It is an injury to the road. Let us not deceive ourselves. It is a device unworthy of the serious builder.

Sand is by no means as useful a bonding material as stone screenings. The sand has not the cementing property that the screenings possess. Sand will aid the road to pack quickly when rolling,

but in wet weather the weakness of the bond becomes apparent. Sand tends to hold the stones apart, rather than to unite strongly together.

Gravel is largely used for roads of light traffic in parts of Canada, and that which packs quickly is very often imagined by road makers to be superior to gravel, which is cleaner, but which packs more slowly. This is always found a mistake, as gravel that packs quickly, as a rule, contains an excess of earth and sand; whereas, it is the stony material that is required on the road. Screened gravel is a more durable material. A much more satisfactory roadbed is produced if stone screenings are obtained from a quarry, by rail or otherwise, to bond the material.

The use of coal tar and asphaltic oils is a practice which has considerably extended of recent years, but is not one which has been generally applied to country road construction in Canada. Macadam roads, built with crude tar, of the usual tarmacadam type, have not as a rule proven a success. The use of refined tars, in which the volatile constituents are removed by distillation, is still in a stage which has not been fully tested by experience. Oils have been used merely to lay dust in a few cases, and not with uniform success.

Present standard Canadian practice still adheres to what is sometimes termed "water-bound" roads; that is, the use of stone screenings well flushed into the interstices of the loose stone, followed by consolidation under a heavy steam roller. The relative values of different rocks for road making depend largely upon the cementing properties of the dust—that produced in crushing, and that ground up by traffic on the roads. Limestone is largely used, and a softer stone with good cementing properties is sometimes found more durable and effective than a harder stone, which lacks the power to cement and re-cement under traffic.

This is one detail in road building, in which future discovery may produce important results. A binding material more effective than stone screenings is greatly to be desired. A material that is durable, tough, elastic, dustless, that seals the surface of the road perfectly, that is unaffected by weather conditions, that combines all these qualities, and is cheap, is the one greatly to be desired addition to the materials of roadmaking.

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